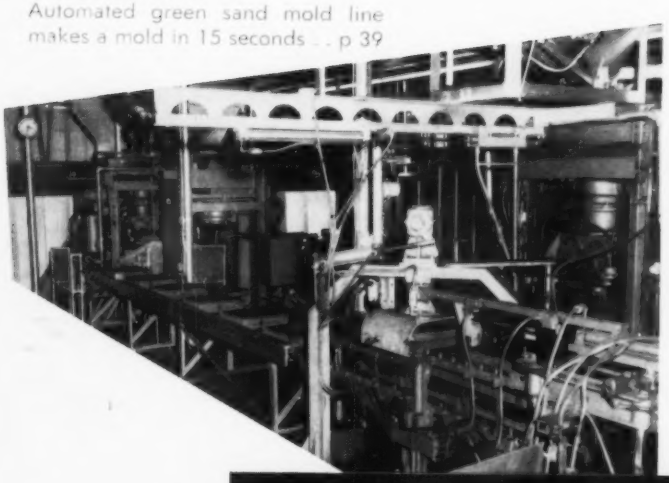
modern castings

AFS JANUARY 1959

Planning for casting inspection by radiation techniques . . p 71

Automated green sand mold line makes a mold in 15 seconds . . p 39



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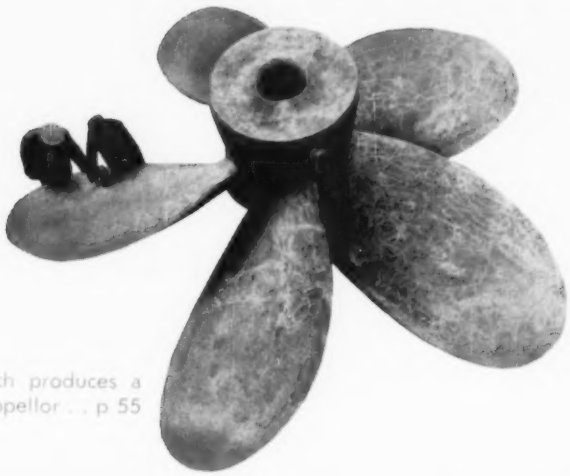
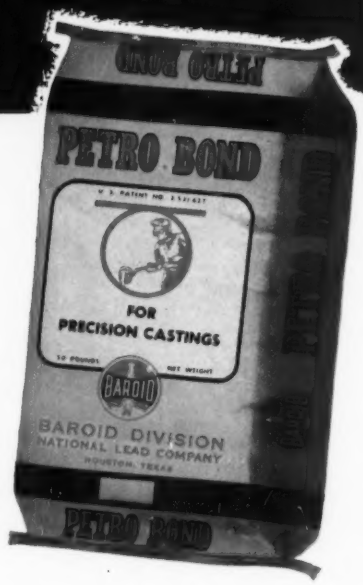


Foundry research produces a super-tanker propellor . . p 55

It's a fact...

Petro Bond* sand assures...Higher Quality Finish In Brass and Bronze Castings



Sands bonded with PETRO BOND use oil instead of water.

PETRO BOND sands . . . produce less gas in the mold . . . therefore finer grain sands may be used resulting in smoother mold and casting surfaces.

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vol. 34, no. 1

modern castings

the technical magazine of the metalcasting industry

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JANUARY

12-16 . . Society of Automotive Engineers, *Annual Meeting & Engineering Display*. Sheraton-Cadillac and Statler Hotels, Detroit.

15 . . . Malleable Founders' Society; *Semi-Annual Meeting*. Cleveland.

26-29 . . *Plant Maintenance & Engineering Show*. Public Auditorium, Cleveland.

30 . . Non-Ferrous Founders' Society, *Management & Operating Conference*. Indianapolis Athletic Club, Indianapolis.

FEBRUARY

2-6 . . American Society for Testing Materials, *Committee Week Meeting*. Penn-Sheraton Hotel, Pittsburgh, Pa.

11 . . AFS Board of Directors, *Spring Meeting*. Palmer House, Chicago.

12-13 . . AFS Wisconsin *Regional Foundry Conference*. Schroeder Hotel, Milwaukee.

15-19 . . American Institute of Mining, Metallurgical & Petroleum Engineers, *Annual Meeting*. Palace Hotel, San Francisco.

18-19 . . Malleable Founders' Society, *Technical & Operating Conference*. Wade Park Manor, Cleveland.

26-27 . . AFS *Southeastern Regional Foundry Conference*. Hotel Tutwiler, Birmingham, Ala.

MARCH

9-10 . . Steel Founders' Society of America, *Annual Meeting*. Drake Hotel, Chicago.

13-14 . . AFS *California Regional Foundry Conference*. Huntington-Sheraton Hotel, Pasadena, Calif.

16-20 . . American Society for Metals, *11th Western Metal Exposition & Congress*. Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles.

16-20 . . National Association of Corrosion Engineers, *Annual Conference & Show*. Chicago.

17-19 . . Investment Casting Institute, *Technical Session*. Los Angeles.

18-19 . . Foundry Educational Foundation, *Annual College-Industry Conference*. Hotel Statler-Hilton, Cleveland.

19-20 . . AFS *Texas Regional Foundry Conference*. Menger Hotel, San Antonio, Texas.

APRIL

6-8 . . . American Institute of Mining, Metallurgical & Petroleum Engineers, *National Open Hearth, Steel Conference*. Hotel Jefferson, St. Louis.

6-10 . . American Welding Society, *Annual Meeting and Welding Exposition*. Hotel Sherman, Chicago.

8-9 . . Malleable Founders' Society, *Market Development Conference*. Hotel Cleveland, Cleveland.

13-17 . . AFS *Engineered Castings Show and 63d Annual Castings Congress*. Hotels Sherman and Morrison, Chicago.

18-22 . . American Society of Tool Engineers, *Annual Meeting*. Schroeder Hotel, Milwaukee.

MAY

13-15 . . National Industrial Sand Association, *Annual Meeting*. The Homestead, Hot Springs, Va.

17-21 . . American Ceramic Society, *Annual Meeting*. Palmer House, Chicago.

25-26 . . Malleable Founders' Society, *Annual Meeting*. The Homestead, Hot Springs, Va.

27-28 . . American Iron and Steel Institute, *Annual Meeting*. Waldorf-Astoria Hotel, New York.

JUNE

9-12 . . Material Handling Institute, *Exposition*. Public Auditorium, Cleveland.

18-20 . . AFS *Foundry Instructors Seminar*. University of Illinois, Urbana, Ill.

21-26 . . American Society for Testing Materials, *Annual Meeting*. Chalfonte-Haddon Hall, Atlantic City, N. J.

25-27 . . AFS *Penn State Foundry Conference*. Pennsylvania State University, University Park, Pa.

SEPTEMBER

24-26 . . AFS *Missouri Valley Regional Foundry Conference*. Missouri School of Mines, Rolla, Mo.

28-Oct. 1 . . Association of Iron and Steel Engineers, *Annual Convention*. Sherman Hotel, Chicago.

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COMPARE SPEED

With the Carver Rapid Muller, you get a batch *every 75 seconds*!

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Only Carver Has Everything For the CO_2 Process!

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We're interested! Rush information on Carver Rapid Muller.

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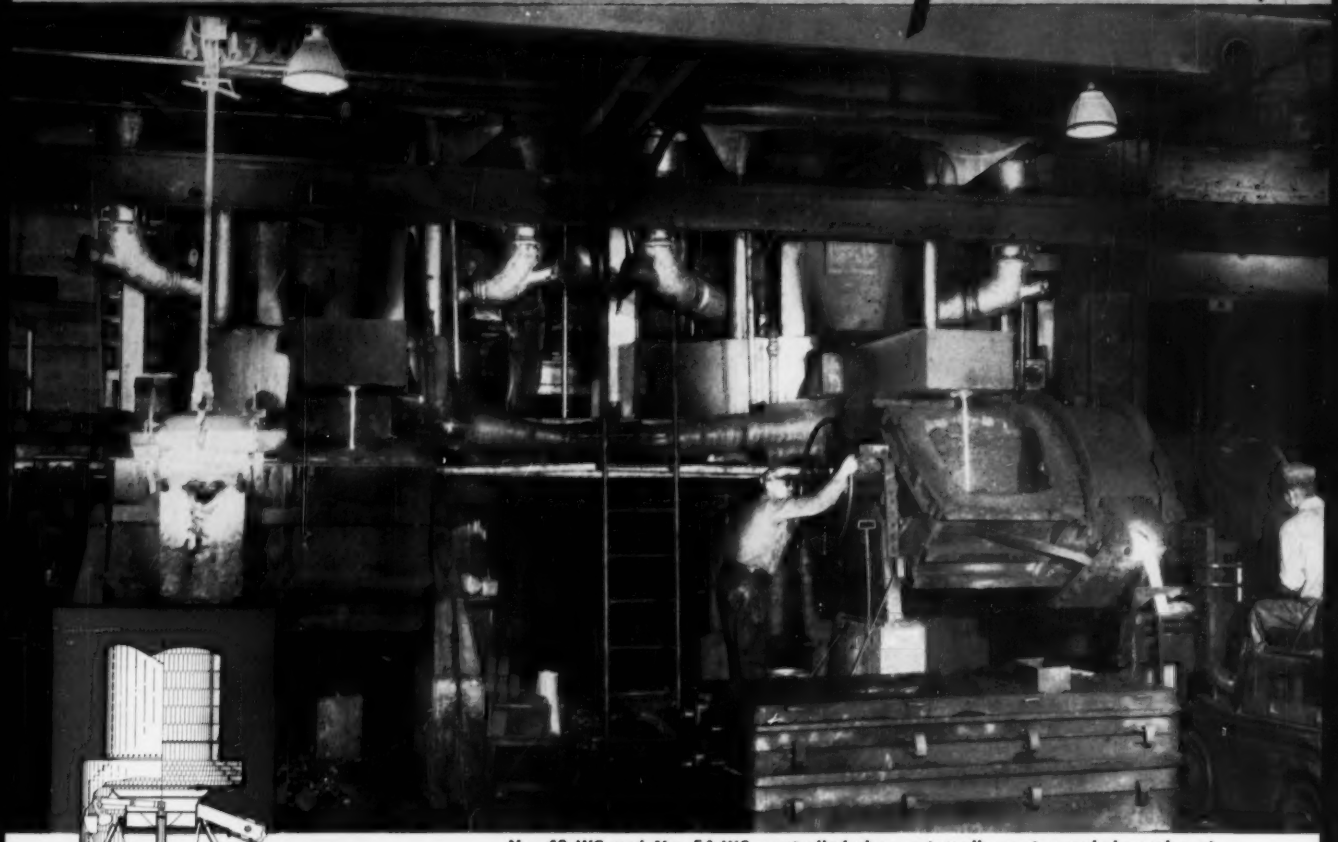
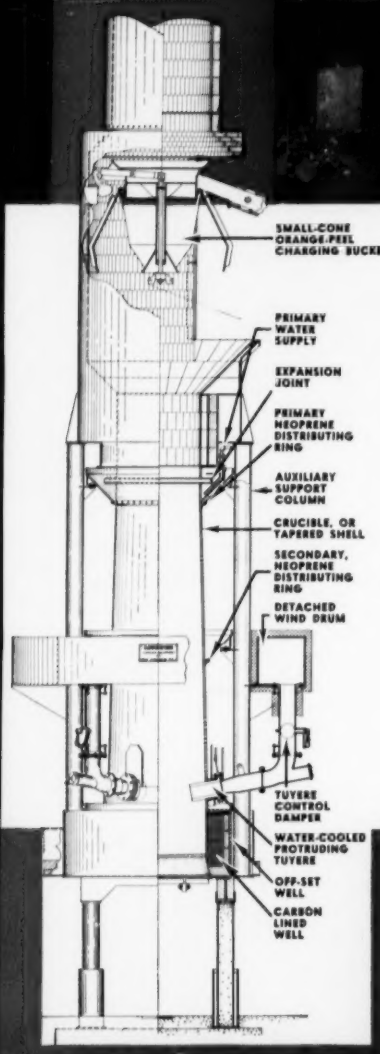
Circle No. 226, Page 155-156

Circle No. 227, Page 155-156 ➡

MODERN Water-Cooled Cupolas for FLEXIBILITY





No. 48-WC and No. 54-WC, controlled slag, externally, water-cooled cupolas at Neenah Foundry — operating with basic, acidic or neutral slags as desired.

JOBBING FOUNDRIES CAN AFFORD IT, TOO!

"can't afford not to MODERNIZE," is the reason as given by Neenah Foundry Company for their change to controlled-slag, externally, water-cooled cupolas. Operating with protruding copper, water-cooled tuyeres and melting directly against the steel shell over-all benefits include:

- ***Greater flexibility and closer control of the melting processes . . .***
- ***Prolonged periods of melting . . .***
- ***Decreased costs for refractory and maintenance . . .***

These major advantages and many more are being enjoyed throughout the major industries and by foundries large and small.

At Neenah Foundry the 8 and 11 TPH MODERN, water-cooled cupolas are operated with basic, acidic or neutral slags as desired. Cupolas remain in continuous operation from Monday morning 'til Friday night. All types of gray iron melted along with base iron for nodular.

All these and other benefits are covered in new bulletin 149-A. Use the coupon or write to Modern Equipment Co., Port Washington, Wis.

MODERN

NEW
Catalog 149-A
Mailed on Request

Modern Equipment Co., Dept. I-1, Port Washington, Wis.

☐ Mail to my attention new catalog 149-A ☐ Mechanical charging ☐ Dust abatement control ☐ Pouring equipment

Company .....

Street ..... Zone .....

City ..... State .....

My Name .....

the editor's report

by Jack Schaum

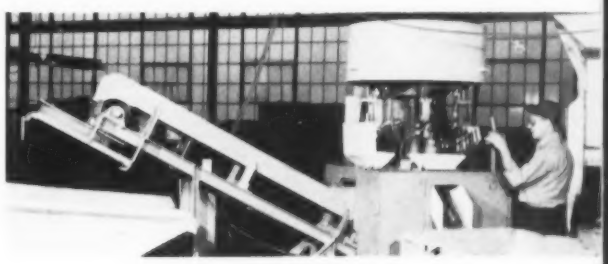
■ **Reliability is being proved by castings in the Atlas intercontinental ballistic missile.** One in particular is a cast stainless steel valve body redesigned from a weldment at a 30 per cent cost saving. Six of the 180-lb valve bodies are centrifugal cast in a 19% Cr-9% Ni stainless alloy. Valve successfully passed rigorous temperature tests ranging from −65 to 500 F, and mechanical tests at 2000 vibrations per second and 15 times the pull of gravity. Pix show "stick" of castings and test tower where casting performance proved satisfactory.

■ **Having trouble** . . . with veining in shell molds and cores? Are they distorting and bulging when hot metal hits them? Then try adding 5 per cent **pulverized slag** from your cupola to the shell sand. John Deere Tractor Works, Waterloo, Iowa, has discovered this remedy which reduces hot expansion of the sand. Another foundry is experimenting with **crushed cupola slag** as a complete substitute for sand in shell molding!

■ They all laughed when the old timer tested the casting by listening to the ring it made when dropped on the floor or struck with a hammer. The old codger was smarter than you think. His trained ear could detect an internal flaw by the tone that resounded. This seemingly crude evaluation of quality has been modernized by electronics at the Central Foundry Division, GMC. The sonic testing machine pictured here automatically checks the soundness of castings by striking the casting a blow and transmitting the sound waves to an electronic device. The casting is automatically accepted or rejected according to the pitch of its sound. **Mechanism is so sensitive that it not only rejects castings with internal flaws but also surface flaws not detectable by other means!**

■ **Steel strapping** . . . is being used by a Texas foundry to hold two halves of split core together instead of paste. Strap is drawn snug around core prints with regular tool used for binding cardboard cartons.

■ **Olivine sand molds** . . . are giving Howard Foundry better finish on aluminum castings than obtained when using permanent molds.



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here's real proof that

Foseco® FEEDEX®

can increase casting yields by 50%

Residual risers on the casting at left are 9" x 4½" and weigh 170 pounds. Risers on the casting at right are 2½" in diameter and weigh 15 pounds. The casting weighs 347 pounds . . . the difference in riser size means the difference between 67% and 96% in casting yield . . . and Foseco FEEDEX made it possible.

FEEDEX is an exothermic anti-piping compound which can be molded to form sleeves or other shapes for application at any position in the mold. Grades for all types of metals are available. Prefabricated FEEDEX Sleeves can also be supplied in a wide range of standard sizes.

Other Foseco exothermic compounds include two high heat producing and insulating hot topping compounds . . . FERRUX for iron and steel and FEEDOL for aluminum and copper based alloys.

FEEDEX, FERRUX and FEEDOL increase casting efficiency by . . .

- eliminating shrinkage
- permitting substantial reduction in riser size so that more castings may be produced from each heat
- reducing cleaning costs
- keeping feed metal molten longer
- aiding directional solidification
- reducing scrap

Write for your free copies of leaflets showing in detail why and how you can increase casting efficiency by using Foseco FEEDEX, FERRUX and FEEDOL.

FOUNDRY SERVICES, INC.
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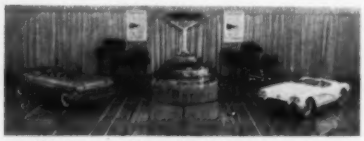
Circle No. 228, Page 155-156

G. M. Institute Annual Banquet

■ Automobile manufacturers are turning more and more to the use of castings. This fact was emphatically dramatized recently in a unique new car and casting display held in conjunction with the G.M.T.E. Foundrymen's Club Annual Senior Banquet sponsored by the General Motors Institute, Flint, Mich.

The exhibit, set up in the Institute gymnasium, featured new models of

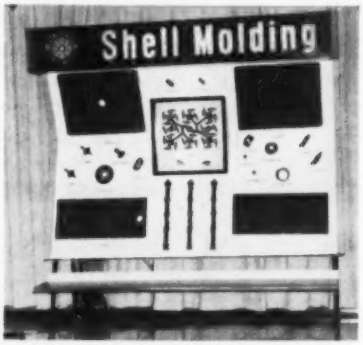


Shiny, new Chevrolets flank gray iron castings used in their construction.

GMC cars together with a display of castings used in each with acknowledgement to the corporation's foundry division furnishing them.

Foundries represented included GMC Central Foundry Div. plants in Saginaw, Mich., Danville, Ill. and Defiance, Ohio. Also the Chevrolet Saginaw Grey Iron Foundry; Pontiac Foundry, Pontiac, Mich.; Cadillac Foundry, Detroit; and Buick Foundry, Flint, Mich.

Souvenirs of miniature molding machines were presented to the 285



GMC's Central Foundry Div. displays small castings made by shell molding.

attending, including Institute seniors and staff, supervisory personnel from the corporation's foundries and guests. The gray iron models were presented through courtesy of Chevrolet Saginaw Grey Iron Foundry, Saginaw, Mich.

MORE FACTS on all products, literature, and services shown in the advertisements and listed in Products & Processes and in For the Asking can be obtained by using the handy Reader Service cards, pages 155-156.

Accurate casting of this 40-lb. rear end housing cuts machining at Auto Specialties.

Quality Controlled HANNA SILVERY... Simplifies Consistent Production of Quality Controlled Castings at Auto Specialties

Much of Auto Specialties Manufacturing Company's fine reputation has been built on the high quality malleable castings produced in huge quantities at its St. Joseph, Michigan, foundry. An important factor in this continuous high quality story is the use of Hanna Silvery. Its dependable analysis plays a major role in the close silicon control of cupola-electric furnace duplexing of malleable, so necessary in the manufacture of precision automotive parts.

Whether they are housings or gears, sprockets, universal joints or clutch plates, quality controlled Hanna Silvery is of vital assistance in maintaining the exacting chemical composition necessary to production of precision castings time after time. This record is substantiated by a million-volt X-ray machine, a part of Auto Specialties quality control system, which spot checks castings for uniformity and accuracy.

Hanna produces high quality pig iron for every foundry need. All regular grades, plus close-grain HannaTite, are available in 38-pound pigs and HannaTen ingots. Trained representatives are ready to help with your metallurgical problems. For assistance, call Hanna today.

Circle No. 229, Page 155-156

Millions of perfect castings at Auto Specialties pass under the eye of this X-ray machine.

THE HANNA FURNACE CORPORATION
Buffalo • Detroit • New York • Philadelphia
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NATIONAL STEEL CORPORATION

Increase Core Production

with the NEW Low-Pressure Air

SHELL CORE BLOWER

The HARRISON 300-H "Cor-Blo"

"Cor-Blo" produces Shell Cores up to 10" in diameter, 12" in height. 6" Draw, 10" Opening between Heater Plates. Larger models also available—Manual, Semi or Full Automatic.

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FEATURES

- **It is now possible to convert many of your present Aluminum Core Boxes into SHELL on our Series 300-H "Cor-Blo".**
- **Harrison Patented Self-Feeder capacity—200 lbs. Resin Coated Sand.**
- **2-Station Shuttle Type for one or two operators.**
- **Each Station has roll-over action, center pivoted.**
- **Powered by air cylinders. Air regulator to select correct blowing pressures for different sized cores.**

In the 300-H HARRISON "Cor-Bo" we have met the need for a low-cost manually operated shell core blower to complete our line of semi and full automatic Shell Core and Mold Machines. It has big output, controlled shell core quality for better castings and will handle different cores at each station. It's built for continuous operation and priced for the smallest foundry with a need for high quality core work.

WRITE FOR FREE BULLETIN 300-H

HARRISON MACHINE CO.

COR-BLO

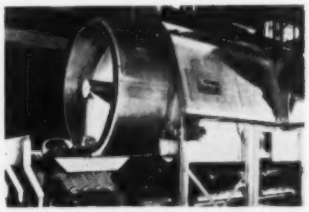
Designers and Manufacturers of a full line of Shell Mold and Core Blowers Manual, Semi or Full Automatic

WESLEYVILLE • ERIE, PENNSYLVANIA

Circle No. 230, Page 155-156

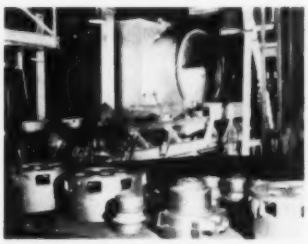
product report . . .

modernization of blast cleaning reduces cleaning costs for the Milwaukee Works, International Harvester Company's Construction Equipment Div., by eliminating costly handling time and reducing labor requirements. Unlike batch units, a continuous barrel handles a steady flow of work coming from the preceding operation, for example, castings from shakeout.



Barrel's end drum, sealed against the blast action, discharges the cleaned castings onto a vibrating conveyor.

As work flows through the barrel at a steady rate, each piece is blasted, the abrasive removed and the work ejected in a constant stream for conveyance to the next operation. The company installed a continuous cleaning barrel to lower cleaning costs and cope with faster production schedules. A 72-in. diameter Rotoblast barrel, manufactured by Pangborn Corp., Hagerstown, Md., has replaced seven tumbling mills and two large batch barrels, reportedly reducing labor requirements by one-third, cutting flood space requirements and reducing maintenance expenses.



Castings move from cleaning barrel in continuous flow to other operations.

The barrel is currently cleaning about 10 tons of castings per hr. It is designed to clean up to 16 tons per hr, depending upon the size and shape of the castings. The unit will handle castings up to 28 in. long. Two Rotoblast wheels, each powered by a 40 hp motor, throw approximately 100,000 lb of steel shot abrasive per hr. Castings cleaned include 200-lb, 27-in. diesel heads; 140-lb steering drum castings; small track idlers; gear housings; sprockets and other parts.

New abrasive can be added while the machine is operating.

For Manufacturer's Information Circle No. 231, Page 155-156

Lowest blast cleaning cost ever with

ROTOBLAST®

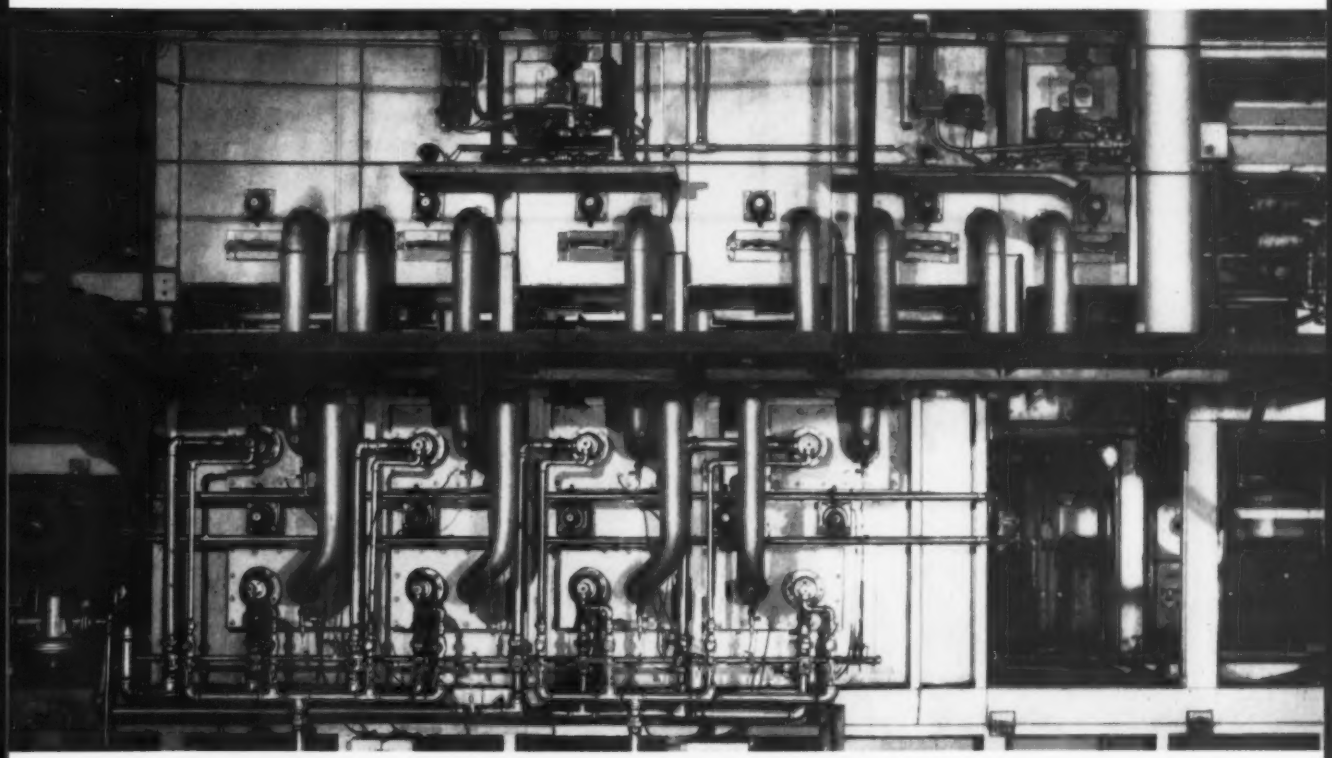
STEEL SHOT

✓ Vacuum Casting

Electric furnace alloy steel, for the first time shotted in revolutionary vacuum chamber for greater density, eliminating voids and defects. You get a fatigue resisting shot for better, faster cleaning.

✓ Continuous Heat Treating in Controlled Atmosphere

Uniform heating for every particle, in controlled atmosphere (zero oxygen), gives you ball bearing, heat treating quality for uniform hardness and longer wear life.



This is one of the new Rotoblast Unit Line Furnaces, the first of their type, with which Pangborn is bringing a new concept of quality to the steel abrasive industry.

Pangborn

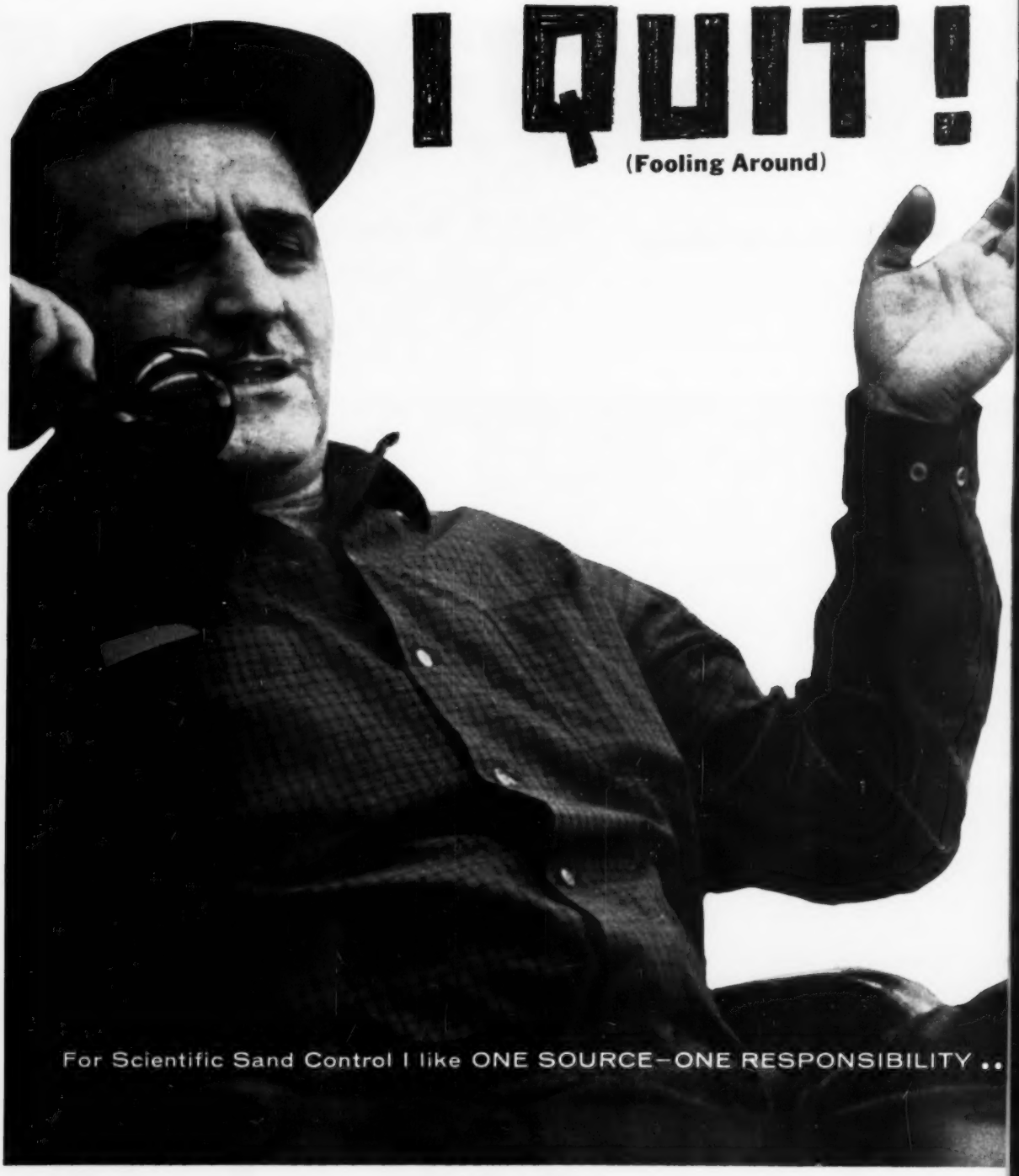
See for yourself! Call the Pangborn Engineer in your area or write PANGBORN CORP., 1300 Pangborn Blvd., Hagerstown, Md.

Rotoblast® Steel Shot

I keep an open mind... try new sand additives when they come along, especially when they promise better castings or lower cost. Any new material that sounds promising gets a fair shake in my foundry. What burns me is to get low quality material or an off-standard batch—means too much readjustment all down the line. There's too much off-standard lately, so—

I QUIT!

(Fooling Around)



Circle No. 232, Page 155-156

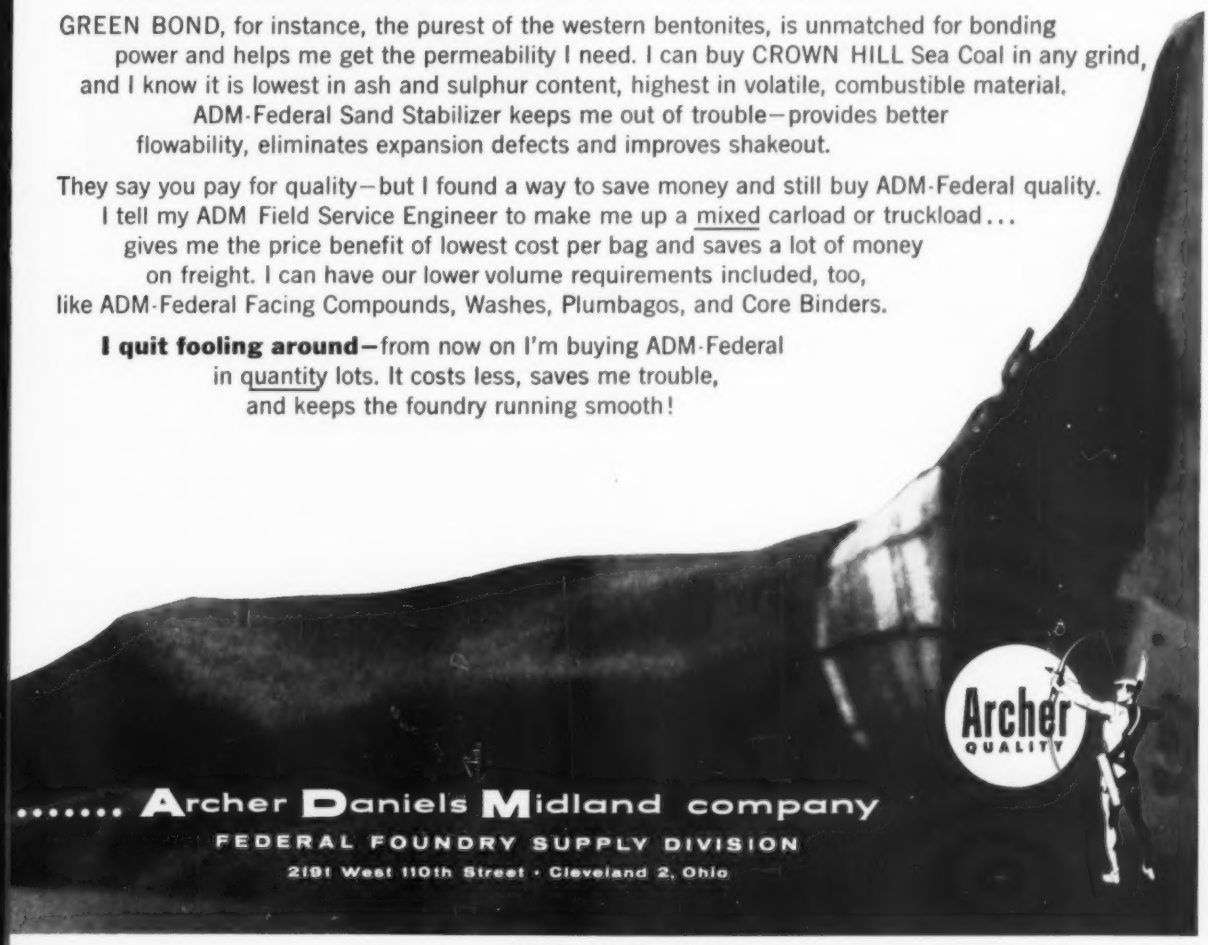
make me up a MIXED TRUCKLOAD of old reliable: Green Bond BENTONITE, ADM-Federal SAND STABILIZER, and Crown Hill SEA COAL

When I use these dependable ADM-Federal products, I know from experience I have perfect sand control. Their absolute uniformity from shipment to shipment assures me of successful duplication of tested sand mixes.

GREEN BOND, for instance, the purest of the western bentonites, is unmatched for bonding power and helps me get the permeability I need. I can buy CROWN HILL Sea Coal in any grind, and I know it is lowest in ash and sulphur content, highest in volatile, combustible material. ADM-Federal Sand Stabilizer keeps me out of trouble—provides better flowability, eliminates expansion defects and improves shakeout.

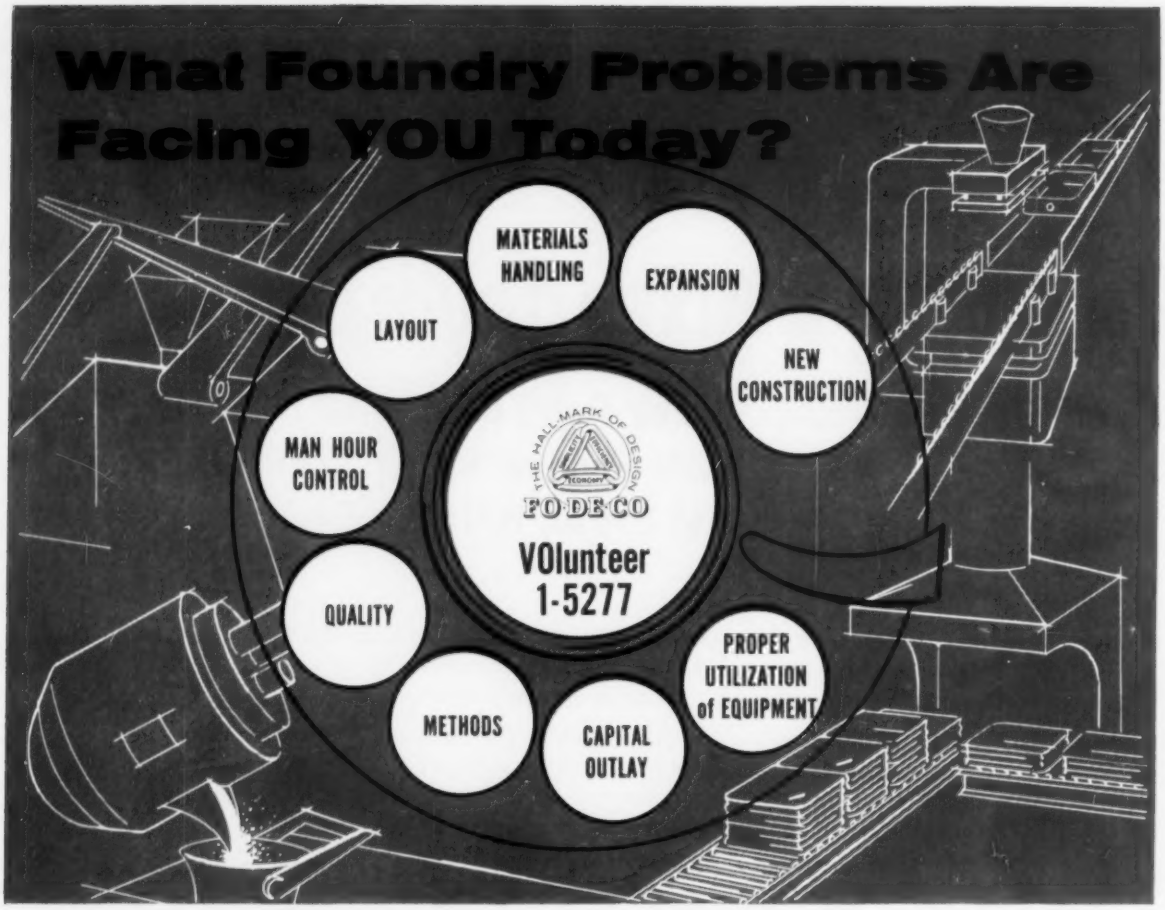
They say you pay for quality—but I found a way to save money and still buy ADM-Federal quality. I tell my ADM Field Service Engineer to make me up a mixed carload or truckload... gives me the price benefit of lowest cost per bag and saves a lot of money on freight. I can have our lower volume requirements included, too, like ADM-Federal Facing Compounds, Washes, Plumbagos, and Core Binders.

I quit fooling around—from now on I'm buying ADM-Federal in quantity lots. It costs less, saves me trouble, and keeps the foundry running smooth!



..... Archer Daniels Midland company
FEDERAL FOUNDRY SUPPLY DIVISION
2191 West 110th Street · Cleveland 2, Ohio

Circle No. 232, Page 155-156



THEIR *Answers* ARE AS CLOSE AS YOUR TELEPHONE!

By contacting FODECO (Foundry Design Co.), you may bring into your plant immediately a foundry engineering service developed by experienced personnel who can offer design ingenuity for special purposes adaptable to your operations.

At all times the objective is to achieve maximum efficiency and coordination in melting—molding—coremaking—cleaning. With such coordination, foundry deficiencies are remedied and production increased. Complete foundry production layouts utilizing existing equipment or guiding alterations, expansion or selection of new equipment are fundamental functions of our service.

Let us arrange for you to visit any of the companies who have availed themselves of our service.

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AMERICAN FOUNDRY & MFG. CO.	St. Louis, Mo.
J. I. CASE CO.	Racine, Wisc.
J. I. CASE CO.	Rockford, Ill.
ELECTRIC STEEL FOUNDRY CO.	Portland, Oregon
ELYRIA FOUNDRY DIVISION OF CHROMALLOY CORP.	Elyria, Ohio
LUDLOW VALVE MANUFACTURING CO., INC.	Troy, N. Y.
MACK TRUCKS, INC.	(Steel Foundry), New Brunswick, N. J.
OTIS ELEVATOR CO.	Yonkers, N. Y.
A. P. SMITH MANUFACTURING CO.	East Orange, N. J.
TOWER GROVE FOUNDRY	St. Louis, Mo.
VIKING PUMP CO.	Cedar Falls, Iowa
WORTHINGTON CORPORATION	Harrison, N. J.
WORTHINGTON CORPORATION	Buffalo, N. Y.
WORTHINGTON CORPORATION	Oil City, Pa.
HONOLULU IRON WORKS CO	Honolulu, T. H.

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Circle No. 233, Page 155-156

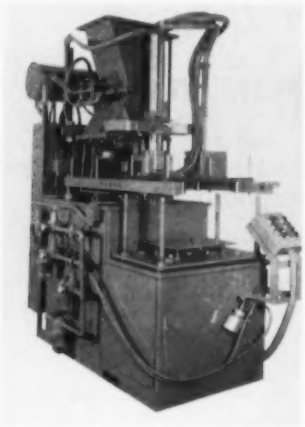
Build an idea-file for improvement and profit. The post-free cards on *the last page* will bring more information on these new . . .

products and processes

GRAPHITE-RESIN PAINT . . . designed to protect coated surface and offer stick-proof base for sand to slide inside bins, hoppers, chutes, core boxes, patterns, conveyors, mullers, etc. Company states need for vibrators reduced, and action of sand against paint causes surface to become more slick. Use circle number below for sample. *Bruce-Conreaux Co.*

For Manufacturer's Information Circle No. 1, Page 155-156

SHELL BLOWING . . . machine which produces shell cores or shell molds automatically said to provide finished product within 30 sec. Two station, rotary shell blower makes



shell cores up to 15 x 20 x 30 in. high, or shell molds up to 16 x 22 x 22 in. draw. Manufacturer claims production rates up to 120 blows per hr, and operation by unskilled labor. *C. & S. Products Co.*

For Manufacturer's Information Circle No. 2, Page 155-156

PLASTIC PANES . . . for use in place of glass are said to eliminate maintenance costs due to glass breakage. Made from polyester resins, fiberglass and nylon strands, the panels are reported by the manufacturer to be easily and quickly installed. *Filon Plastics Corp.*

For Manufacturer's Information Circle No. 3, Page 155-156

HOSE AND CABLE MAINTENANCE . . . facilitated with one-piece clamp. Said to be capable of rapid application and removal without special tools—holding strength above hose bursting pressures. *Circle Clamp Corp.*

For Manufacturer's Information Circle No. 4, Page 155-156

WOOD PATTERN SEALING . . . said to be successful when plastic sealing compound is sprayed on patterns. Best results reported when compound is rubbed down with wax and polished. *Furane Products, Inc.*

For Manufacturer's Information Circle No. 5, Page 155-156

SURFACE PYROMETER . . . double range instrument designed for plant and laboratory surface and sub-surface temperature measurements alike. Low-range for 0-500 F, and the high range calibrated from 0-1500 F. Constructed in dust, moisture and shock-resistant shielded steel housing. Available with 15 interchangeable and flexible, rigid extension arms. *Pyrometer Instrument Co.*

For Manufacturer's Information Circle No. 6, Page 155-156

HARD SURFACING . . . of steel parts with new powder having a high content of tungsten carbide. Officials state only a thin coating, applied by metal spraying equipment, is needed for wearproofing. Surfaces cannot be machined, but can be ground to close tolerances by diamond or silicon carbide. Foundry applications include protecting surfaces subjected to severe abrasion. *Kennametal Inc.*

For Manufacturer's Information Circle No. 7, Page 155-156

AIR BLOW GUN . . . with new pistol design and easy operating mechanism claimed by manufacturer to offer natural grip with slight finger pressure, affording amount of air desired

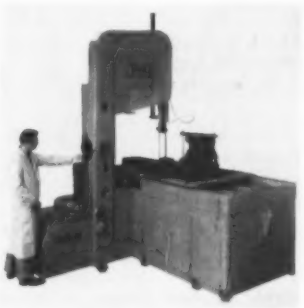
regardless of flow or pressure. Aluminum gun available with 10-in. extension nozzles. *Perfecting Service Co.*

For Manufacturer's Information Circle No. 8, Page 155-156

PLASTIC SAND BINDER . . . designed for use with castings where precision is important, can be used with aluminum, magnesium, brass, bronze, malleable iron, gray iron, steel and steel alloys. Reported advantages include elimination of blow holes and obnoxious fumes; provides fine surfaces, dimensional stability, excellent collapsibility and shakeout; requires no critical oven temperature; is stable in storage and safe to use. *B. F. Goodrich Chemical Co.*

For Manufacturer's Information Circle No. 9, Page 155-156

CASTING SECTIONING . . . for destructive testing of castings with complex cores is reportedly speeded with new machine designed for rapid sectioning of iron, steel and aluminum castings. Features 36-in. work



height allowing sectioning of high castings plus table feed providing rates from 1 in. to 8 ft per min. Company claims saw band can be changed when necessary without disturbing setup. *DoAll Co.*

For Manufacturer's Information Circle No. 10, Page 155-156

FERROUS METAL PLATING . . . reportedly offers maximum resistance to corrosion, oxidation and abrasion. Also applicable to copper. Manufacturer states that upon plating, mild steel will serve where only stainless steel would do. Nickel composition material is brushed, dipped or sprayed on metal surface and heated to 1650 F, forming nickel alloy plate said to make impossible any cracking, chipping, peeling or lifting of the plate. Sharp edges and internal and external threads may be

plated without build-up of sharp surface, company states. *Systems Co.*

For Manufacturer's Information
Circle No. 11, Page 155-156

CHROMIUM ADDITIONS . . . for steel and cast iron. High-carbon ferrochrome alloy reportedly is a low-cost source of chromium for stainless steel base charges. According to manufacturer, the tough alloy structure prevents breaking up in the cupola; high chromium recoveries (85-90 per cent) are obtained consistently. Crushed sizes available for ladle additions. *Electro Metallurgical Co.*

For Manufacturer's Information
Circle No. 12, Page 155-156

HEAVY-DUTY DRILL PRESS . . . attachment provides slow-speed operations on 20-in. press. Attachment offers speeds from 70 to 2600 rpm for foundry operations such as reaming or trimming castings. *Rockwell Mfg. Co., Delta Power Tool Div.*

For Manufacturer's Information
Circle No. 13, Page 155-156

SPECTROCHEMICAL ANALYSIS . . . by optical emmission vacuum quantometer reportedly gives analysis of P, S and C as well as all other elements important to metalcasting. Precision and accuracy said to be unexcelled by other routine procedures. Complete analysis of iron or steel available in 2 min. *Applied Research Laboratories, Inc.*

For Manufacturer's Information
Circle No. 14, Page 155-156

OIL-GAS BURNER . . . pulsating-type unit, reported to be capable of far higher flame temperatures than previously possible with gas or oil. Produces powerful luminous flame with 3450 F peak temperature (oil), and over 3300 F with natural gas. Available for heat release rates ranging up to 70,000,000 Btu's per hr. *E. W. Bliss Co.*

For Manufacturer's Information
Circle No. 15, Page 155-156

RESISTS MOLTEN ALUMINUM . . . low expansion ceramic materials withstand temperatures at 1830 F continuous rate, and to peaks of 2100 F. Because of resistance to molten aluminum, company states materials are being investigated for use as furnace linings for aluminum melting tanks and for molten aluminum containers. *Corning Glass Works.*

For Manufacturer's Information
Circle No. 16, Page 155-156

METAL TUMBLING MEDIA . . . reportedly offer up to 10 times longer life than conventional media, while permitting simpler, standardized production of barrel finished parts. Produced by sintering process which officials state permits precise control of material hardness, shape, porosity and

Ride the UPSWING at the Engineered

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More people . . . 4,000,000 babies yearly. In the past 50 years, U. S. population has doubled, and our prosperity curve always follows our population curve.

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Approximately 100 papers will be presented at sessions that will be featured throughout this 5-day meeting . . . practical, workable ideas that are applicable to problems of modern design and production:

- Aluminum and Magnesium Casting Properties
- Aluminum Casting Designs to Resist Vibration
- Casting Design
- Cupro-Nickel Alloys for Weldability, Castability and Mechanical Properties
- Design Engineering as Related to Magnesium Castings
- Design of Gray Iron Castings
- Die Castings Design and Properties of Light Metals
- Ductility and Strength of High Carbon Gray Irons
- Effect of Shape Factor on Properties of Light Metal Castings
- Electrical Conductivity of Copper-Base Alloys
- Elevated Temperature Properties of Cast Iron
- How Aircraft Designers Look at Light Metal Castings
- Interrelation between Stress Construction and Castability
- Machinability of Cast Iron
- Machining of Standard and Pearlitic Malleable Iron . . . Measuring Machinability . . . What Machinability Data is Available . . . Solving Machining Problems
- Martensitic White Irons for Abrasion Resistant Castings
- New Propellor Alloys
- Preliminary Appraisal of Bending Techniques for Evaluation of Cast Materials and Structure
- Properties of Centrifugally Cast Light Alloys
- Properties of Investment Castings
- Quality Control of Castings
- Relation of Composition and Microstructure of Gray Iron to Machinability in One-Inch Rounds
- Section Strength of Bronze Castings
- Special Centrifugal Castings Containing Gray Cast Iron
- Surface Finish Measurements
- The Manufacture and Application of Brass and Bronze Castings (annual lecture)
- Ultrasonic Inspection
- Welding and Brazing of Cast Iron for Mechanical Strength

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You'll see an entire industry prove . . . *Casting is the shortest distance between raw material and finished product!*

You'll gain a new appreciation of the quality . . . the utility . . , the economy of cast metal for your new product concepts.

WHAT IT IS

The ENGINEERED CASTINGS SHOW is an exclusive industrial exhibit, concurrent with the 63d AFS Castings Congress. On display, ready for side-by-side evaluation, will be the greatest array of engineered castings ever assembled. Here, you'll see hundreds of examples of the value of cast metal in precision product development.

HOW IT HELPS

Because cast metal is basic to all fields of manufacture, The ENGINEERED CASTINGS SHOW is a versatile industrial development tool. Here, the latest technology . . . the newest applications of cast metal, will lead to advanced planning and stimulate new product ideas. Here, Product-Design Engineers and Castings Producers will exchange ideas for solving design and engineering problems . . . to achieve greater efficiency . . . effect new savings.

WHO WILL COME

Here is a combination event directly appealing to Product-Design Engineers and Castings Users from General Industry. It offers them an "education" in cast metals . . . on-the-spot study of practical metal applications . . . opportunities to learn about cost-cutting techniques for achieving improved product applications . . . five days to evaluate casting for the manufacture and assembly of machinery, equipment and appliances.

WHERE IT APPLIES

This exclusive industrial exhibit penetrates into the core of the expanding Original Equipment Market. Analysis of the 1957 ENGINEERED CASTINGS SHOW indicates broad industrial appeal:

Agricultural Equipment
Air Conditioning Equipment
Aircraft
Appliance
Automotive
Baking
Bottling
Brewing and Distilling
Business Machines
Canning
Ceramics Machinery
Chemical Processing Machinery
Compressors, Engines & Pumps
Construction
Dairy Products Machinery
Electrical
Elevator
Food Processing

continued

Hardware
Heating
Hydraulic & Pneumatic Equipment
Instrument
Laundry
Leather Working
Lumber and Saw Mill Machinery
Machine Tools
Marine
Materials Handling
Metalworking
Military Equipment
Mining
Musical Instruments
Nuclear Science Equipment
Ordnance
Packaging
Paint Making Machinery
Paper Making Machinery
Petroleum Equipment
Photographic Equipment
Printing Machines
Power Equipment
Radio and Television
Railroad
Refrigeration
Road Building and Maintenance
Rubber Processing
Telephone and Telegraph
Textile Machinery
Tobacco Processing Machinery
Waterworks Equipment
Woodworking Equipment

WHAT THEY DO

The ENGINEERED CASTINGS SHOW is a presentation of the vital developments within the castings industry during the past two years. Integrated with the AFS Castings Congress, it enables Product-Design Engineers and Castings Buyers to see and study what's new . . . to meet and talk with production foundrymen . . . to apply the latest thinking to their own research and development activities. Job titles from the 1957 ENGINEERED CASTINGS SHOW attendance types the average audience:

Castings Buyer
Castings Designer
Castings Expeditor
Castings Inspector
Chemical Eng.
Chief Eng.
Cost Analyst
Design Analysis Supt.
Design Eng.
Development Eng.
Die Cast Eng.
Director of Purchases
Electronic Engrs.
Engineering Co-ordination
Field Eng.
Materials Eng.
Metallurgist
Methods Eng.
Mgr. Contract Manufacturing
Process Eng.-Castings
Product Application Research Eng.
Production Eng.
Project Eng.
Quality Coordinator
Research Eng.
Tool Eng.

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in '59 Castings Show

This Event Will Influence Your Future Progress

Castings Producers Can Afford to be Optimistic

100,000 copies of this booklet will be sent to Product Design Engineers, pointing up the advantages of THE ENGINEERED CASTINGS SHOW.

These Product-Design Engineers must keep informed about the advantages of castings—their futures depend on a diversified knowledge of production methods. They must be able to judge the advantages of castings—components and end products—for their own design concepts.

THE ENGINEERED CASTINGS SHOW provides an exclusive industry-wide exhibit . . . a made-to-order market place, where Castings Producers can meet and exchange ideas with Product-Design Engineers.

Copies of this folder will be sent to the customers of any Castings Producer. Simply send in the names to National Headquarters . . . copies will be mailed without charge, or fill in and mail the postcard in the folder.

The 1959 ENGINEERED CASTINGS SHOW, combined with the 63d AFS Castings Congress, is a sales development project that will benefit *every* Castings Producer. Act now to be a part of this far-reaching event.

Meet the thousands of Product-Design Engineers who will be in Chicago—April 13-17—to study and discuss the advantages of castings. In short, ride the upswing in '59!

CASTINGS SHOW

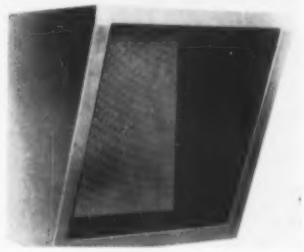
FOUNDRYMEN'S SOCIETY

DES PLAINES, ILL.

surface characteristics to produce media for particular cutting, deburring and finishing applications. *Dixon Sintaloy, Inc.*

For Manufacturer's Information Circle No. 17, Page 155-156

PLANT PHONE BOOTH . . . or intercom enclosure is acoustically conditioned to cut noise levels by as much as 50 per cent, according to



manufacturer. Two-in. walls constructed of perforated steel and sound absorbing material. *Suttle Equipment Corp.*

For Manufacturer's Information Circle No. 18, Page 155-156

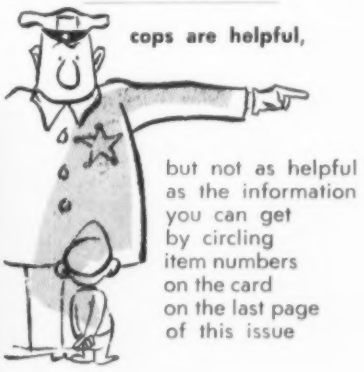
WEATHERPROOF MOTOR . . . for use where motor is subjected to extreme moisture or the elements. All external parts of corrosion-proof cast iron. Features non-washing grease in bearings. Grease automatically metered in proper amount from large reservoirs, say company officials. *Reliance Electric & Engineering Co.*

For Manufacturer's Information Circle No. 19, Page 155-156

RUST PREVENTIVE SPRAY . . . non-flammable, non-toxic, packaged in aerosol container, claimed to give positive protection from rust for all types of metal. In most cases, protective film does not have to be removed before use or final finishing. *Lehigh Chemical Co.*

For Manufacturer's Information Circle No. 20, Page 155-156

CORROSION RESISTANT VALVES . . . of new plastic materials resist corrosive action of alkalis, acids, and corrosive fluids in oil, gas and chemicals. Also nodular-iron valves, com-


cops are helpful,
but not as helpful as the information you can get by circling item numbers on the card on the last page of this issue

AIRETOOL
PNEUMATIC TOOLS
do 9 hours work in 8

The powerful air motors used in Airetool pneumatic tools step up operator production without increase in fatigue. They deliver constant speed over long work periods . . . without heat-up or stall. And lightweight, balanced-design Airetool production tools handle comfortably and easily—take lots of abuse with no loss in efficiency. As a result, Airetool users report an extra hour's production in a day's work.

HORIZONTAL GRINDERS

For general grinding, snagging, buffing and wire wheel work, 4" to 8" wheel capacity.

VERTICAL GRINDERS

For cup and depressed center wheels, grinding, sanding and wire wheel work. 6" wheel and 7 to 9" sanding disc capacity.

MIDGET DIE GRINDERS

For intricate precision grinding, filing and cutting jobs with carbide burrs and abrasive wheels. 38,000 to 60,000 rpm operation.

PNEUMATIC DRILLS

High efficiency, portable models. 5/32, 3/16, 1/4, 1/2, 5/8 and 3/4" capacities.

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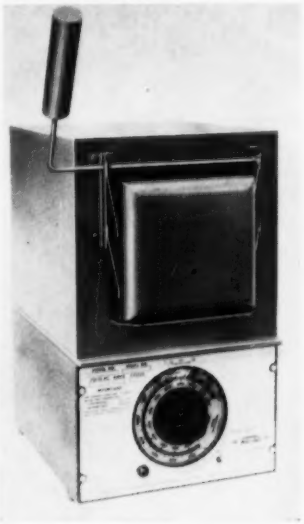
CANADIAN PLANT: 37 Spalding Drive, Brantford, Ontario

Circle No. 234, Page 155-156

bines corrosion resistance with machineability and, according to company test, ability to retain original dimensions when heated to 1350 F and suddenly quenched. *Walworth Co.*

For Manufacturer's Information Circle No. 21, Page 155-156

LABORATORY FURNACE . . . features dialing of temperature desired up to 1900 F and safety door which swings out and up, keeping hot side



away from operator. Portable unit has 4 x 3-3/4 x 9-in. chamber size, plugs into standard outlet of proper voltage. *Thermo Electric Mfg. Co.*

For Manufacturer's Information Circle No. 22, Page 155-156

PLASTIC PROTECTIVE COATING . . . formulated from a special blend of silicones and epoxies, reportedly has demonstrated outstanding properties for corrosion and impact resistance, long life, and is weather and moisture resistance. Will not chip or peel when bent or dented. *Mono-Seal Products.*

For Manufacturer's Information Circle No. 23 ,Page 155-156

PLATFORM TRUCK . . . with 7500-lb capacity for skids or racks features power steering, electric starter and differential said to allow either wheel to drive the truck if the other is on ice, grease or is unable to get traction. Standard platform, 28 in. wide and 60 in. long. Other sizes available. Two speeds in forward and reverse, speeds up to 10 mph. *Truck-Man Lift Trucks.*

For Manufacturer's Information Circle No. 24, Page 155-156

BOTTOM DUMPING HOPPER . . . is used in conjunction with fork-lift truck hydraulic attachment to store foundry materials in over-head bins. Attachment lifts bottom-dumping container so that materials spill out into bin. Truck may also be used in conventional fork-lift operations with attachment intact. *Yale & Towne Mfg. Co.*

For Manufacturer's Information Circle No. 25, Page 155-156

ROLLER STORAGE RACKS . . . and electric lift truck combine to ease handling of heavy castings, patterns, fixtures, etc., according to manufacturer. Trucks, operated by walking behind them, have 3000-lb capacity and maneuver in aisles 5-3/4 ft wide, depositing loads on roller storage racks. *Lewis-Shepard Products, Inc.*

For Manufacturer's Information Circle No. 26, Page 155-156

LIFT TRUCK . . . constructed with heavy-duty frame said to provide better stability through low-level weight mass. Maximum stacking height of over 131 in. Company claims new mast provides increased operator visibility. *Allis-Chalmers Mfg. Co.*

For Manufacturer's Information Circle No. 27, Page 155-156

POWER BOOST . . . for electric industrial trucks possible with new high-capacity storage batteries. Through use of batteries reportedly providing up to 45 per cent more power, company claims significant increase in amount and variety of workload that can be handled plus power needed for truck power attachments. *Exide Industrial Div., Electric Storage Battery Co.*

For Manufacturer's Information Circle No. 28, Page 155-156

MAGNETIC PARTICLE TESTING . . . kit for portable detecting of cracks in ferrous parts. Applicable for heavy equipment overhaul inspection, light weld inspection and

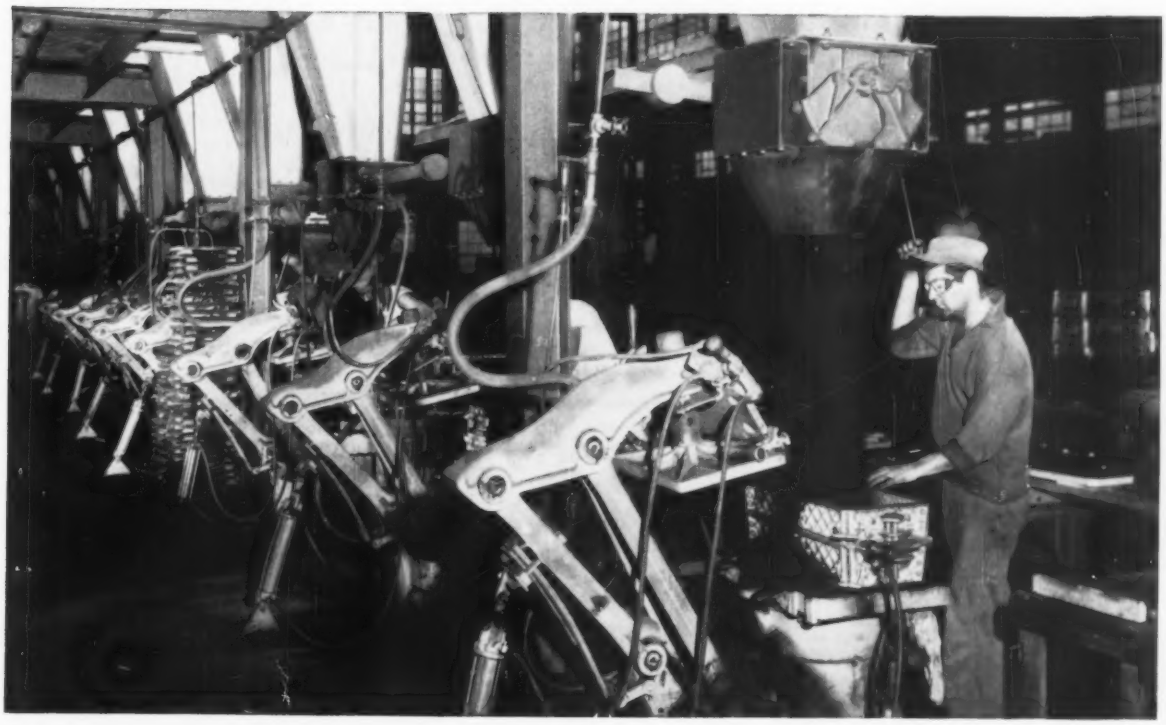
inspection of castings. Unit demagnetizes parts after inspection completed—cracks detected by applying inspection medium and observing powder indications. *Magnaflux Corp.*

For Manufacturer's Information Circle No. 29, Page 155-156

SAFETY GOGGLES . . . designed for heavy industrial operations, cup-type goggles have high impact resistance and their contour design

Continued on page 20

JEFFREY helps modernize
A. C. Williams Co. foundry at Ravenna, Ohio



Jeffrey hoppers supply sand directly to molders' stations; save considerable time, effort and floor space.

Jeffrey MV conveyors move material with non-sliding, hopping action that assures long deck life; abrasive wear is negligible.

Jeffrey equipment played a major part in improving plant efficiency when A. C. Williams Co. modernized its foundry. Jeffrey overhead sand distributing systems, MV conveyors, aerators and apron conveyors are being used.

You can call on Jeffrey for equipment or for complete system engineering to improve efficiency and to boost profit. Jeffrey engineers are thoroughly familiar with all phases of foundry operations. Jeffrey-built equipment is expressly designed for the high-speed, low-maintenance operation modern foundries require.

Complete information on Jeffrey foundry equipment and service is described in Catalog 911. Write for your copy. The Jeffrey Manufacturing Company, 907 North Fourth Street, Columbus 16, Ohio.

JEFFREY

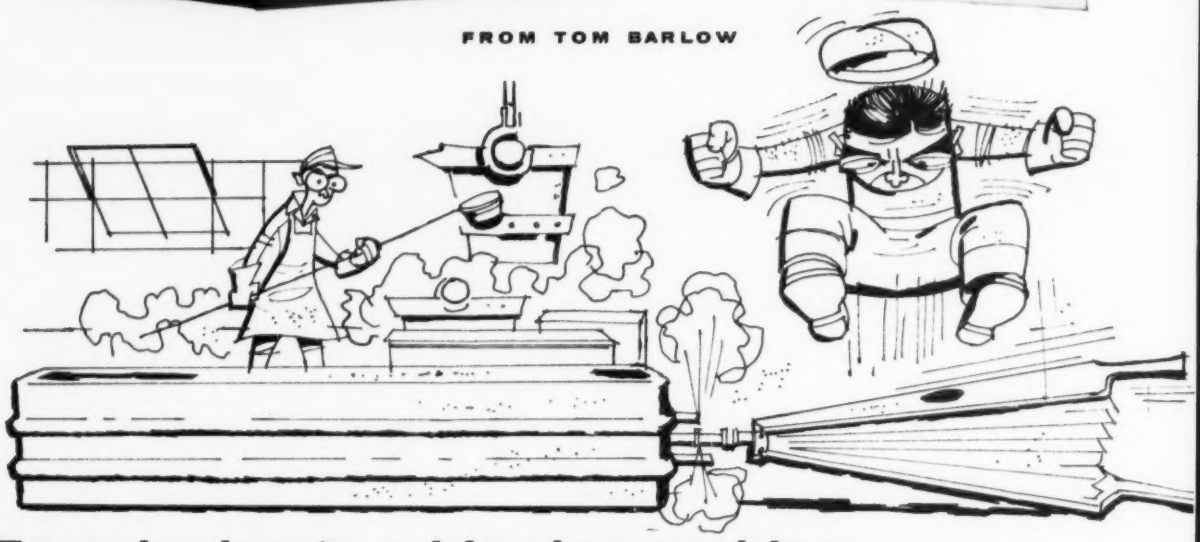
CONVEYING • PROCESSING • MINING EQUIPMENT . . . TRANSMISSION MACHINERY . . . CONTRACT MANUFACTURING

Circle No. 235, Page 155-156

International Minerals & Chemicals

A REPORT TO FOUNDRIES

FROM TOM BARLOW



Foundry beats a blowing problem:

no more "green sand blues"

Blowing of green sand certainly isn't a common foundry occurrence. But where it's encountered, it can cause real headaches. For that reason, we're proud of the record of our service people who are able to demonstrate "overnight" the ability of Plasti-Bond to impart "blowability" in green sand for this special and very difficult task.

Here's a recent example. One of our customers had a ticklish blowing operation — difficult because it involved filling a cavity over six feet long and with only a two-inch opening. To complicate matters even more, blowing had to be accomplished from one end.

First they tried to reduce the green strength, but no go — hardness wasn't sufficient to withstand metal penetration at the end farthest from the blow holes. Just one answer: Change the sand.

Plasti-Bond came through, all right . . . in a sand having a green strength of 10 to 11 pounds, a moisture of 4.5 to 5. And while these details may concern only foundries faced with that particular problem, there's a moral to the story for all foundrymen. It's the fact that this special additive, Plasti-Bond, can make sand do tricks that can't be brought off any other way. Perhaps you have an unusual sand problem with which we might demonstrate the same success.

Rules out ram-offs!

Many a foundryman goes wrong in his thinking on sands by assuming that they transmit a squeeze pressure in all directions, like fluids. Tain't so. Actually, sand transmits most of its pressure in a direct line, with very little of that energy moving sideways.

Sure, this feature is improved greatly by additives such as Triplact and Plasti-Bond. But it's still true that mold pressure from the squeeze or packing from the jolt is essentially in a *vertical* direction, and not necessarily toward the pattern. (This varies, of course, with sand flowability.) As a result, any pre-packing or shift of force after the preliminary jolt or squeeze will create a ram-off condition. This is described by the AFS as "a casting defect resulting from a section of the mold being forced away from the pattern by ramming sand after it is formed to the pattern contour."

Because of the design and patented features of the Taccone Diaphragm Machine, the molding is always toward the pattern — never past it or away from it. For this reason, ram-offs are impossible.

If you'd like a complete description of this and the many other features of the Taccone machine, drop us a card. We'll send the full story on high-pressure molding.

Circle No. 236, Page 155-156

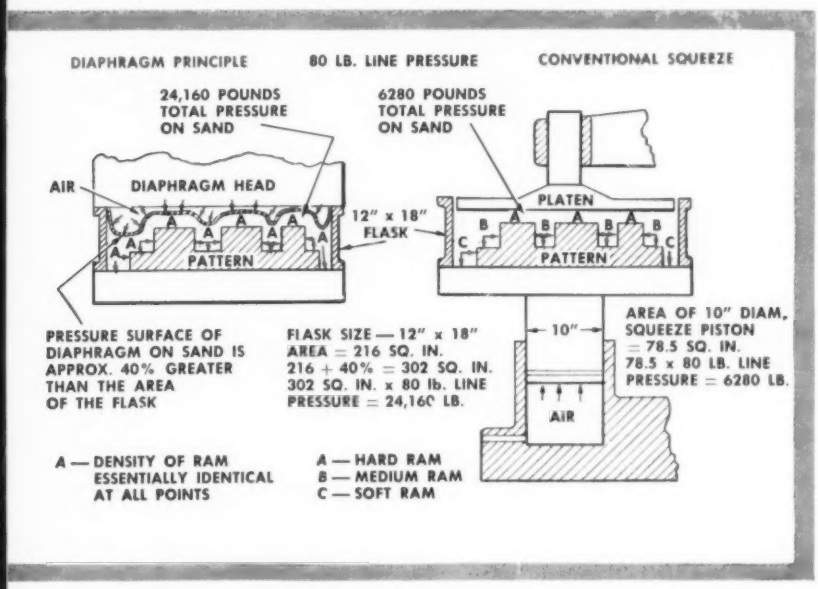
Ten year old granddaddy

Over 10 years ago, a new Eastern Clay product called Westonite made quite an impact on this industry. It gave the foundryman finish, flowability and casting appearance that promised to revolutionize the entire method of molding. There are still several foundries using this carbon-bonded sand because it's especially suited to their operation. But since little is heard about it lately, we get questions which add up to "Wha hoppen?"

In principle, Westonite continues to grow. Or — to use a homely simile — Westonite lives on through its children and grandchildren. Newer additives are actually outgrowths of this original chemically bonded sand. Today they are widely used to provide peel or cleaning action . . . to give flowable, fast molding, easy shakeout and controlled moisture sands. Matter of fact, in looking over literature on Westonite's advantages, we find a complete description of the advantages of Triplact, Plasti-Bond and Z-Flo.

Since originating this concept of molding, Eastern Clay has never let up in research and development work. In the future, we will no doubt come out with new and superior products that will push the basic benefits of these additives even further. Every application brings a more complete knowledge of what makes these things tick.

If you're interested in the technical aspects of Plasti-Bond, we'd like to send you a copy of a Foundry Magazine reprint, "Recent Developments in High Pressure Molding" by Tom Barlow. If you're concerned only with making better castings at lower cost without delving into the "whys" or "hows," we'd like the chance to make a demonstration in your own plant.


DIAPHRAGM PRINCIPLE
80 LB. LINE PRESSURE
CONVENTIONAL SQUEEZE
24,160 POUNDS TOTAL PRESSURE ON SAND
6280 POUNDS TOTAL PRESSURE ON SAND
AIR
DIAPHRAGM HEAD
12" x 18" FLASK
PLATEN
PATTERN
PATTERN
PRESSURE SURFACE OF DIAPHRAGM ON SAND IS APPROX. 40% GREATER THAN THE AREA OF THE FLASK
FLASK SIZE — 12" x 18"
AREA = 216 SQ. IN.
216 + 40% = 302 SQ. IN.
302 SQ. IN. x 80 lb. LINE PRESSURE = 24,160 LB.
10"
AREA OF 10" DIAM. SQUEEZE PISTON = 78.5 SQ. IN.
78.5 x 80 LB. LINE PRESSURE = 6280 LB.
AIR
A — DENSITY OF RAM ESSENTIALLY IDENTICAL AT ALL POINTS
A — HARD RAM
B — MEDIUM RAM
C — SOFT RAM

A coupla cupola cues

If you look upon patching of the cupola as a necessary evil, you've got company. Most foundrymen do. But good patching is no accident — it's based on modern, scientific knowledge. In fact, it's an important function in the control of metallurgical properties and the chemistry of the castings you sell.

Remember, the quality of patching material may affect the melting rate. It influences temperature, uniformity and cleanliness of molten metal while controlling the rate of silicon and manganese losses and phosphorous pick-up.

Moreover, good patching is always cheapest, because the quality of the material controls bridging, erratic analysis and many other cupola ills. Besides, you can have top quality patching materials at only a shade over the initial cost of the cheapest local "muds." The longer life gained is well worth it.

But cost is secondary. Without a doubt, the most important value of good mixes is good metallurgical control. At the same time, it's the most frequently overlooked virtue.

We'd be glad to show you how our Cupoline patching mix might add an "extra" to the quality of your castings.

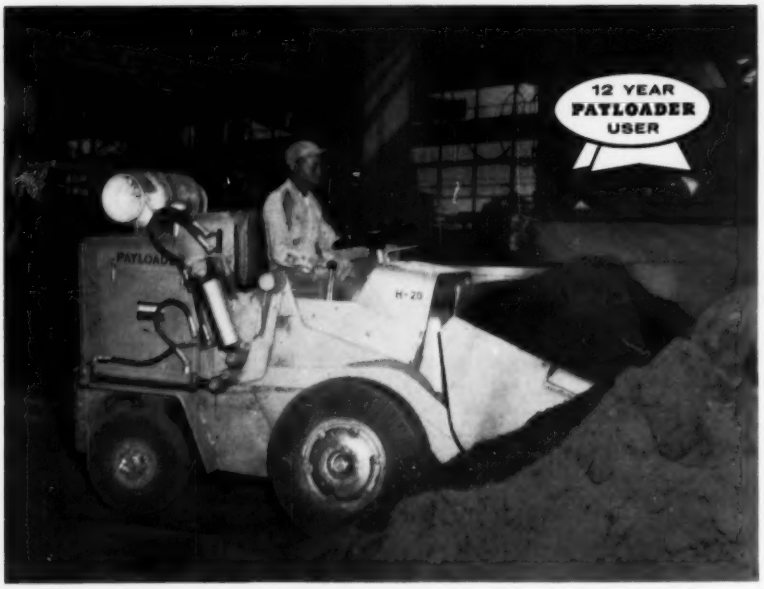
MINERALS International CHEMICALS

CREATORS OF LIVING MINERALS

EASTERN CLAY PRODUCTS DEPT.

INTERNATIONAL MINERALS & CHEMICAL CORPORATION

Administrative Center, Old Orchard Road, Skokie, Illinois • ORchard 6-3000



124-year-young foundry uses newest PAYLOADER®

The Taylor & Fenn Co. of Windsor, Conn., although one of the oldest foundries in the United States, is also one of the most progressive. For example, 12 years ago they bought one of the first "PAYLOADER" tractor-shovels — at that time a new idea in flexible, low-cost sand handling.

Recently they bought a Model H-25 "PAYLOADER" — the last word in tractor-shovel design and productivity. This modern machine has a carry capacity of 2,500 lbs. — the highest capacity-to-weight ratio ever attained in tractor-shovel design — yet accomplished without any increase in turning radius. In fact, it is even more maneuverable and faster and easier operating because of power-steering and power-shift transmission with 2-speeds both forward and reverse.

Other outstanding features of the H-25 that will benefit The Taylor & Fenn Co. and *all* users of this new "PAYLOADER" model are power-transfer differential, more powerful hydraulic bucket control and the fullest system of air and oil filters and grease seals for long-life protection and low maintenance.

Your "PAYLOADER" Distributor will be glad to show you why a model H-25 will give you more for your money. Ask him about Hough Purchase and Lease Plans too.

HOUGH®

THE FRANK G. HOUGH CO.
LIBERTYVILLE, ILLINOIS
SUBSIDIARY — INTERNATIONAL HARVESTER COMPANY

THE FRANK G. HOUGH CO.
711 Sunnyside Ave., Libertyville, Ill.

Send me more data on the model H 25

Name _____

Title _____

Company _____

Street _____

City _____

State _____

1-A-2

Circle No. 237, Page 155-156

Products and Processes

Continued from page 16

guarantees safety and fitting comfort, according to company officials. *Bausch & Lomb Optical Co.*

For Manufacturer's Information Circle No. 30, Page 155-156

RESONANCE BONDING . . . of mold and core sands hardens sand without use of heat, ovens or gassing equipment. Manufacturer claims setting and hardening time can be adjusted to suit individual needs by means of "delayed chemical action," and that materials and principles of new process reduce hardening time of shell molds. Process claimed to increase size and reduce cost of investment castings, and to result in use of finer sands. *Coldhard-HiUtek Div., United States Trading & Service Corp.*

For Manufacturer's Information Circle No. 31, Page 155-156

METAL-FILLED EPOXY . . . resins designed to make strong castings with properties similar to metal. Make molds for short-run use and for filling voids and plugging holes in metal structures, wood, plastics. Two-component material cures at room temperature and is said to have excellent machining properties. Sets in four hr at 70 F, one hr at 120 F. *American Latex Products Corp.*

For Manufacturer's Information Circle No. 32, Page 155-156

SHELL MOLD . . . release agent eliminates sticking, break-in, build-up and cleaning of shell mold patterns and core boxes. Applied by spray or brush, coating tested to withstand temperatures over 1000 F. Smokeless, non-toxic, inert. *Chem-Cote Co.*

For Manufacturer's Information Circle No. 33, Page 155-156

BALL BEARING COMPASS . . . precision drafting instrument permits drawing of perfect circles, 1/4 to 2-in. diameters by inserting pencil in desired hole and spinning around center. Offers choice of 69 diameters. *F & H Mfg. Co.*

For Manufacturer's Information Circle No. 34, Page 155-156

CO_2 MOLD CURING . . . gassing unit reportedly cures molds stripped or on the pattern. Features adjustable height, blank-off-blocks which reduce excess chamber space and stop cam for arresting inward movement of mold. *Alphaco, Inc.*

For Manufacturer's Information Circle No. 35, Page 155-156

EPOXY MOLDING . . . compound reportedly offers for the first time high strength coupled with exceptional conformability. Users report average flexural strength of 100,000 psi,

Continued on page 22

A Timely Message For Foundry Managements

what are YOUR foundry problems?

Check this list of KNIGHT SERVICES FOR FOUNDRIES

- ☐ Plant Layout
- ☐ Cost Control
- ☐ Methods
- ☐ Modernization
- ☐ Mechanization
- ☐ Materials Handling
- ☐ Automation
- ☐ Organization
- ☐ Production
- ☐ Job Evaluation
- ☐ Wage Incentive

The quickest, easiest and most practical way to solve any foundry problem that is restricting your production or increasing your costs is to use the dependable services of experienced Knight Engineers. Regardless of the type or size of your foundry—or your problems—Knight Engineers can be of unusual help.

For consultation on any foundry problem, large or small, call on Lester B. Knight & Associates, Inc.

Lester B. Knight & Associates, Inc.

Management, Industrial and Plant Engineers

Member of the Association of Consulting Management Engineers, Inc.

549 W. Randolph St., Chicago 6, Ill.
917 Fifteenth St., N.W., Washington, D.C.
New York Office—Lester B. Knight & Associates, 375 Fifth Ave., New York City 16
Knight Engineering Establishment (Vaduz), Zurich Branch, Bahnhofstrasse 17, Zurich, Switzerland
Lester B. Knight & Associates, G.M.B.H., Berliner Allee 47, Düsseldorf, Germany

Circle No. 238, Page 155-156

FOUNDRYMAN'S RIDDLE

What costs just a few cents per ton of metal yet increases fluidity of slag, gives greater tensiles, reduces sulphur, improves machinability of gray iron castings?

ANSWER →

don't accept substitutes

IF YOU MELT ALUMINUM OR BRASS

...Try *Famous* CORNELL Aluminum or Brass Flux

Write for Bulletin 46-A

DAWSON-MacDONALD CO.
141 PEARL STREET, BOSTON 10, MASS.
Now Representing The Cleveland Flux Company in the Following States: Maine, Massachusetts (except Everett), Vermont, New Hampshire, Rhode Island

FAMOUS CORNELL FLUXES
Trade Mark Registered

The* CLEVELAND FLUX *Company
1026-40 MAIN AVENUE, N. W. • CLEVELAND 13, OHIO
Manufacturers of Iron, Semi-Steel, Malleable, Brass, Bronze, Aluminum and Ladle Fluxes—Since 1918
Circle No. 239, Page 155-156

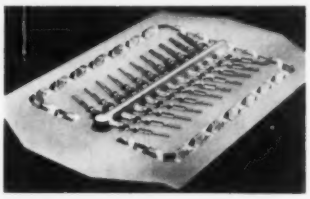
Products and Processes

Continued from page 20

average tensile strength of 40,000 psi and average compressive strength of 38,000 psi at normal temperatures. Glass content, 66 per cent; resin content, 34 per cent. Manufacturer states that once molded, the material offers the good dimensional stability characteristic of epoxy resins. *Minnesota Mining & Mfg. Co.*

For Manufacturer's Information Circle No. 36, Page 155-156

NON-SHIFT PATTERNS . . . feature unique sand lock system consisting of series of small offsets around



the border of the pattern plate. Offsets, one in. long, extend alternately into cope and drag, reportedly giving freedom from mold handling shift. *Scientific Cast Products Corp.*

For Manufacturer's Information Circle No. 37, Page 155-156

PORTABLE BRINELL HARDNESS TESTING . . . said to offer new opportunities for more rigid inspection and control. Designed for rough shop or field use where material to be tested is stationary, heavy or odd-shaped preventing conventional BHN measurements. Unit includes carrying case, bar holder, anvil, microscope with etched scale, three test bars and computer. *Teleweld, Inc.*

For Manufacturer's Information Circle No. 38, Page 155-156

ALUMINUM SCAFFOLDING . . . of welded tubular aluminum construction. Varieties of portable and sectional products include pyramid arrangements of 29-in. span scaffold and high clearance scaffolds. *Aluminum Safety Products, Inc.*

For Manufacturer's Information Circle No. 39, Page 155-156

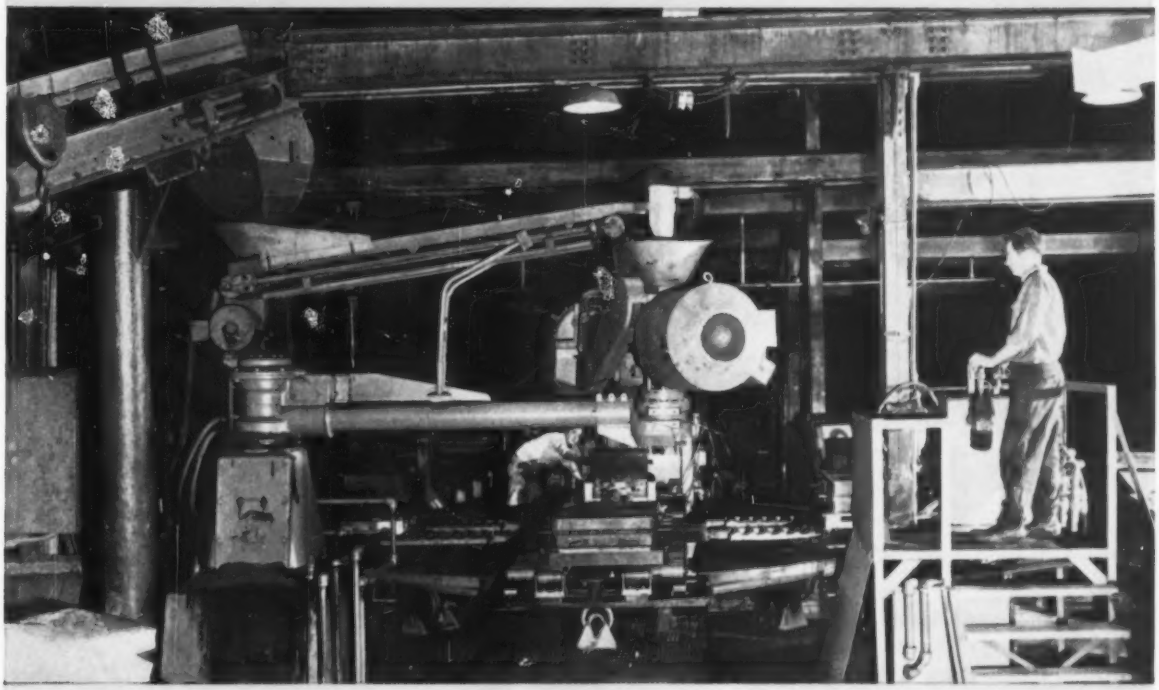
don't be left behind!

don't miss a thing! send for manufacturer's info by circling numbers on card, last page this issue

GO OUT AND BUY CASTINGS?

BUILD A NEW PLANT?

MECHANIZE EXISTING PLANT?



BROWN & SHARPE'S CHOICE...

Inadequate foundry facilities left Brown & Sharpe, one of the world's outstanding machine tool producers, with only three courses. They would have to go out and buy castings from a jobbing foundry, build a new foundry, or completely revitalize their existing set-up through mechanization.

A staff of engineers studied the problem thoroughly. Because of the difficulties involved in developing new casting sources for their quantity and type of castings, a new foundry looked like the only way out, yet, management knew that the huge investment required would create a real overhead problem.

Then, the engineers investigated the tremendous flexibility and low cost of Hydra-Slinger mechanization. Mechanization of the existing foundry became the only logical course to follow. Now, Brown & Sharpe's largest molds—weighing up to five tons—are made on a Hydra-Slinger "Figure 9" Loop Conveyor Unit. Smaller work is handled on a Hydra-Slinger Roto-Mold Unit, served by a B&P Rol-A-Draw. An added assurance of quality and production is provided by a Model "60A" Speedmullor, which prepares the foundry's molding sand.

Brown & Sharpe's mechanization has paid off.

1. They avoided the huge investment required by a new plant.
2. Existing space and facilities have been utilized to provide all of the production needed.
3. The company has been able to obtain cost and control advantages by producing its own castings.

B&P mechanization can pay off in other ways, too. Write now!

BEARDSLEY & PIPER

Div. Pettibone Mulliken Corp.
2424 N. Cicero Avenue
Chicago 39, Illinois

B&P

Circle No. 240, Page 155-156

let's get personal

John Wishart . . . has joined the Foundry Products Div., Reichhold Chemicals (Canada) Ltd., Toronto, and will initially direct the sales and

John Wishart

service in Ontario. He has been associated with foundry activity for 20 years, with extensive experience in foundry sand technology.

A. P. Gagnebin . . . has been elected vice-president and **J. M. Weldon** elected assistant vice-president of International Nickel Co., Inc., New York. Gagnebin has been associated with the firm since 1930 and has devoted himself to research on ferrous metals. A co-inventor of ductile iron, he has been active in its industrial development. Gagnebin was awarded the Peter L. Simpson Gold Medal of AFS for outstanding work and development in this field. He is the author of many technical papers and the book *The Fundamentals of Iron and Steel Castings*. Weldon has been with the firm since 1927. In 1952 he was appointed technical advisor to the Nickel Conservation Panel of the Minerals and Metals Advisory Board of the National Research Council of National Academy of Sciences.

J. L. Stroman . . . has been added to furnace staff of Hevi-Duty Electric Co., Milwaukee, as furnace consultant. **J. C. Smith,** former sales manager, will handle sales of Stroman furnaces for Hevi-Duty. **John Denizen,** former manager of Stroman combustion engineering department, will work as senior design engineer and **H. R. Kaht, Jr.,** with sales engineering at the same firm, will assist Smith in Hevi-Duty sales dept. Announcement of these positions was made subsequent to the acquisition of Stroman Furnace & Engineering Co., by Hevi-Duty Electric Co.

F. W. Ellis . . . has been appointed foundry sales representative, Climax Molybdenum Co., New York, for the Dayton, Ohio area. Ellis has broad experience covering many aspects of foundry operations.

C. R. Slater . . . has been promoted to manager of the Melrose Park (Ill.)

C. R. Slater

works of National Malleable & Steel Castings Co., Cleveland. Slater has been with the firm since 1933.

H. E. Barnum . . . has been appointed to the post of assistant manager, foundry div. by Vanadium Corp. of America, New York. His new responsibilities include iron and steel foundry activities of the corporation.

V. H. Patterson . . . has been appointed metallurgical engineer and will headquarter in the company's Chicago office.

Ralph Rathyen . . . Joseph Dixon Crucible Co., Jersey City, N. J., has been promoted to post of industrial sales manager. He will head sales activities of three Dixon divisions: paints, crucible and refractories, and graphite and lubricants. Prior to this promotion Rathyen was manager of crucible and refractories division.

P. G. Jacka . . . Herman Pneumatic Machine Co., Pittsburgh, Pa., has

P. G. Jacka

been appointed general manager. He will headquarter in company's Zelienople, Pa., plant.

J. T. Sabol . . . has been appointed district manager of Inductotherm' Corp.'s Delanco, N. J., newly-created Cleveland district office. He is a member, AFS Northeastern Ohio Chapter.

L. F. Harding . . . sales engineer with the C. O. Bartlett & Snow Company's Detroit office since 1952, has been transferred to the Chicago district office in Oak Park, Ill.

R. Zufra, . . . comptroller, National Metal Abrasive Co., Cleveland, was recently elected to assistant treasurer for the firm.

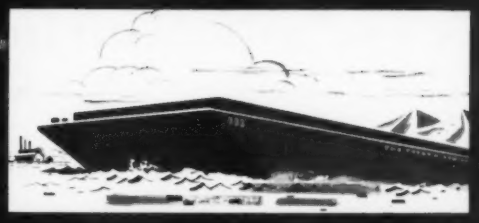
R. J. Enroth . . . joined the sales force of Whiting Corp., Harvey, Ill., and will work primarily in engineered sales products.

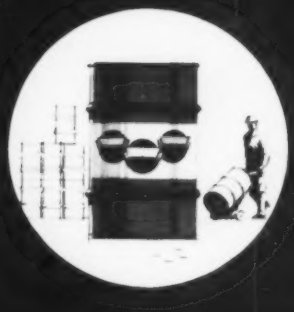
D. G. Wiggins . . . Metallurgical Sales & Service Co., Hamilton, Ontario, is the new Canadian representative, Davis Fire Brick Co., and affiliated companies. He will handle sales and technical knowledge of refractory requirements.

R. W. Thomas . . . has been appointed sales representative for the Bay City Foundry Co., Bay City, Mich. His territory will consist of the eastern half of Pennsylvania, Maryland, Delaware and New Jersey.

Don Johnson . . . has been promoted to sales manager, Almco, Queen Products Div., King-Seeley Corp., Albert Lea, Minn. He will assume direct

Continued on page 28

BY  THE BARGELOAD OR...

BY THE DRUM,  YOU

CAN COUNT ON QUALITY

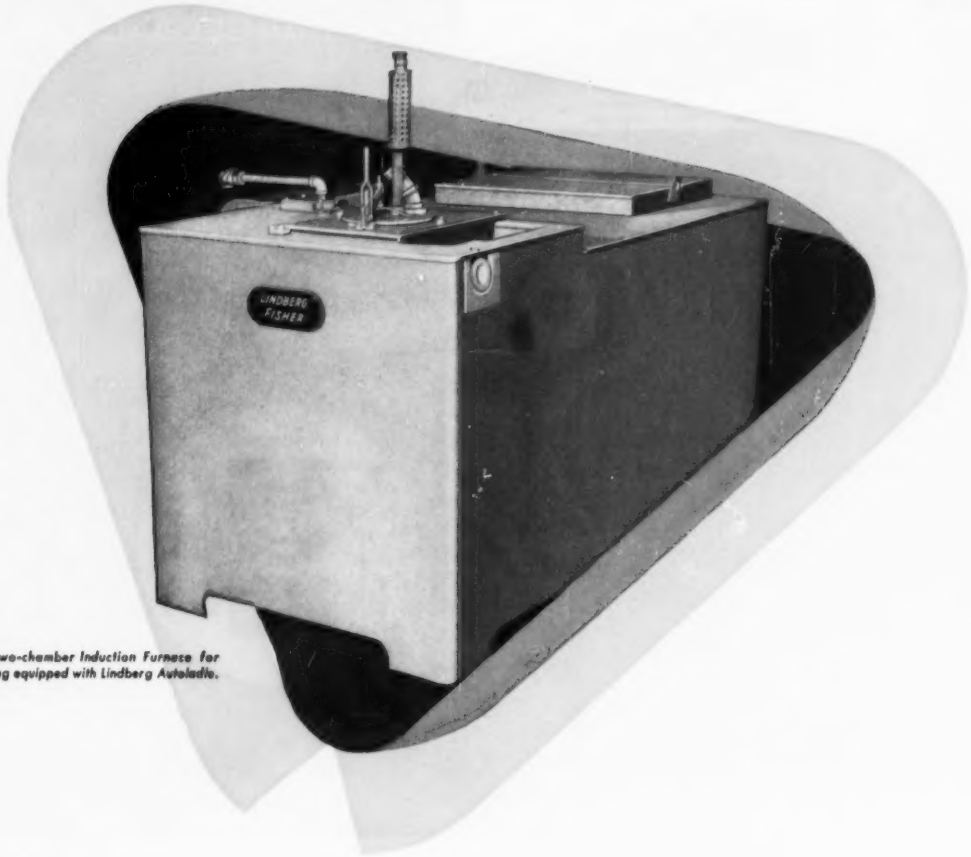
Whether you order 500 pounds or 500 tons from Ohio Ferro-Alloys, you can always count on: 1) Meticulously careful attention to your order; 2) Complete, experienced metallurgical assistance; 3) Consistently high and uniform quality. At Ohio Ferro-Alloys our attitude is this: the most important order we get is **your** order.

Ohio Ferro-Alloys Corporation
Canton, Ohio

BIRMINGHAM • CHICAGO • DETROIT
LOS ANGELES • PHILADELPHIA • PITTSBURGH
SAN FRANCISCO • SEATTLE

Circle No. 241, Page 155-156

Here's the ideal combination for casting aluminum automatically



Lindberg-Fisher two-chamber Induction Furnace for melting and holding equipped with Lindberg Autoladle.

Do you die-cast aluminum? Then take Lindberg's famous two-chamber induction melting and holding furnace, add "Little Joe" Lindberg's new automatic pump, and you'll have the most efficient automatic combination anywhere. The Lindberg-Fisher two-chamber furnace *melts* in one chamber, *holds* metal at precisely the right temperature in the other chamber, and "Little Joe" automatically delivers exactly the right size shot to the casting machine. With this combination all handling of molten metal is eliminated, perfect control of metal temperatures and shot size is maintained, and all automatically. For safer, more economical, more precise handling of aluminum or any non-ferrous metals or alloys better see Lindberg. Just get in touch with the Lindberg plant or the Lindberg Field Representative in your locality, or write Lindberg-Fisher Division, Lindberg Engineering Company, 2440 West Hubbard St., Chicago 12, Illinois. Los Angeles Plant: 11937 S. Regentview Ave., at Downey, California.

LINDBERG heat for industry

Circle No. 278, Page 155-156

When aluminum needs heat treating it's time to look to LINDBERG

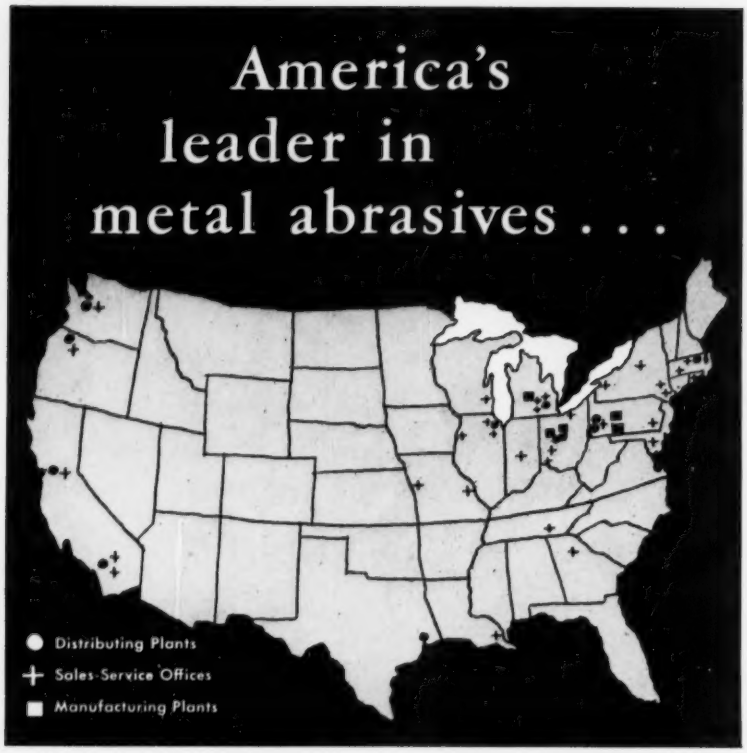
Lindberg Cyclone batch type furnace for heat treating aluminum castings.

When your use of aluminum makes it essential to apply heat for annealing or stress relief Lindberg can come up with the right equipment to do the job. Whatever the requirement our long experience in the application of heat to all types of metal can provide you with just the right furnace to fill your specific need. Maybe the batch type furnace shown here is what you need, or a big bottom quench for treating large aluminum sheets. No matter, Lindberg's staff of engineers, metallurgists and research technicians will face up to your problem. They'll help you find the answer, too, with the right type of equipment to treat aluminum or aluminum alloys to exact requirements of your product. Just get in touch with the Lindberg plant or the Lindberg Field Representative in your locality. Lindberg Engineering Company, 2440 West Hubbard St., Chicago 12, Illinois. Los Angeles Plant: 11937 S. Regentview Ave., at Downey, California.

LINDBERG

heat for industry

Circle No. 278, Page 155-156



For over 70 years, Pittsburgh Crushed Steel Company has consistently led the metal abrasives industry—has led in research and product development—has led in the improvement of production methods—and has led in sales and service facilities as well as in distribution facilities!

The results have been better metal abrasives for lower cleaning costs in foundries, forge plants, and steel and metal working plants in general!

Today, through 13 distributing points and 33 sales-service offices, we supply all sizes and types of metal abrasives, iron and steel, for every type of blast-cleaning equipment and for every blast-cleaning requirement!

Our engineering, sales, and service representatives are always available to you in connection with your blast-cleaning needs.

PITTSBURGH CRUSHED STEEL COMPANY

Arsenal Sta. Pittsburgh (1), Pa.
Subsidiaries: Globe Steel Abrasive Co., Mansfield, Ohio
Steel Shot Producers, Arsenal Sta. Pittsburgh, Pa.

MALLEABRASIVE | **TRU-STEEL SHOT** | **SAMSON SHOT** | **ANGULAR GRIT**

Circle No. 343, Page 155-156

let's get personal

Continued from page 24

supervision of field sales and dealer services. **Al Sartor** has been promoted to branch manager of the Detroit operation servicing Michigan, Ohio, Indiana and western Pennsylvania. **Bruce Hardin** also advanced to sales engineer of the Michigan area and **George Shelson** to sales coordinator. Shelson will have direct supervision of the Almco home office.

J. C. Moroso . . . has been appointed general products manager, Electro Metallurgical Co., Div., Union Carbide Corp., New York. In his new assignment, Moroso will be responsi-

J. C. Moroso

ble for operation of sales control, marketing research groups and the newly-formed product management groups, as well as assisting the direct supervision of the field sales organization.

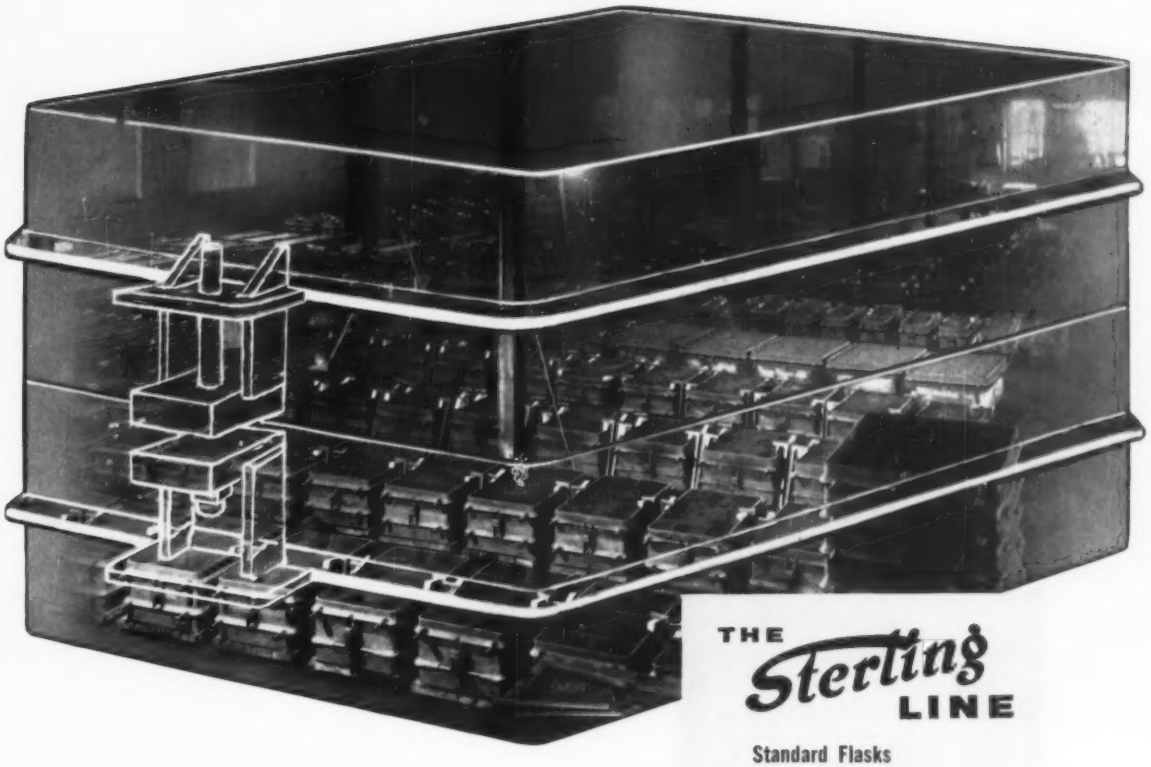
K. "Red" Herron . . . is the new Cleveland district sales manager, Alloys & Chemical Mfg. Co., Cleveland. In this capacity he will be responsible to the president for all A. & C. aluminum and zinc-alloy ingot sales and service to sand, permanent mold and diecast foundry and steel-mill installations.

Harold Browning . . . recently became associated with Bay City Foundry Co., Bay City, Mich., in the position of general superintendent.

G. L. Teller's . . . appointment as purchasing agent of foundry products and supplies, Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has been announced. He succeeds **F. K. Schroeder,** who retired after 16 years service.

W. C. Hookway . . . director of product engineering, Cooper Alloy Corp., Hillside, N. J., has been made head of the consolidated product

Continued on page 144



THE Sterling LINE

- Standard Flasks
- Heavy Duty Flasks
- Stack Molding Flasks
- Steel Flask Bars
- Flask Clamps
- Clamping Bars
- Pins and Bushings
- Steel Core Plates
- Bottom Boards
- Bands
- Upsets
- Slag Buggies
- Heavy Duty Wheelbarrows
- General Wheelbarrows
- Core Trucks
- Casting Carts
- Casting Trucks
- Pneumatic & Steel Wheels

Look into your foundry needs!

Now is the time to check your foundry requirements so you'll surely be prepared for the business boom that's bound to come . . . *and it may conceivably be soon.*

For almost 50 years, foundrymen all over the world have looked to Sterling for their flasks and other foundry needs. They have always had complete confidence in Sterling's soundly engineered equipment and high quality standards. They specify Sterling because they know it's TOPS in the industry.

Your files are incomplete without a copy of the Sterling Catalog. It describes the complete Sterling line listed here. Write for your copy — today.

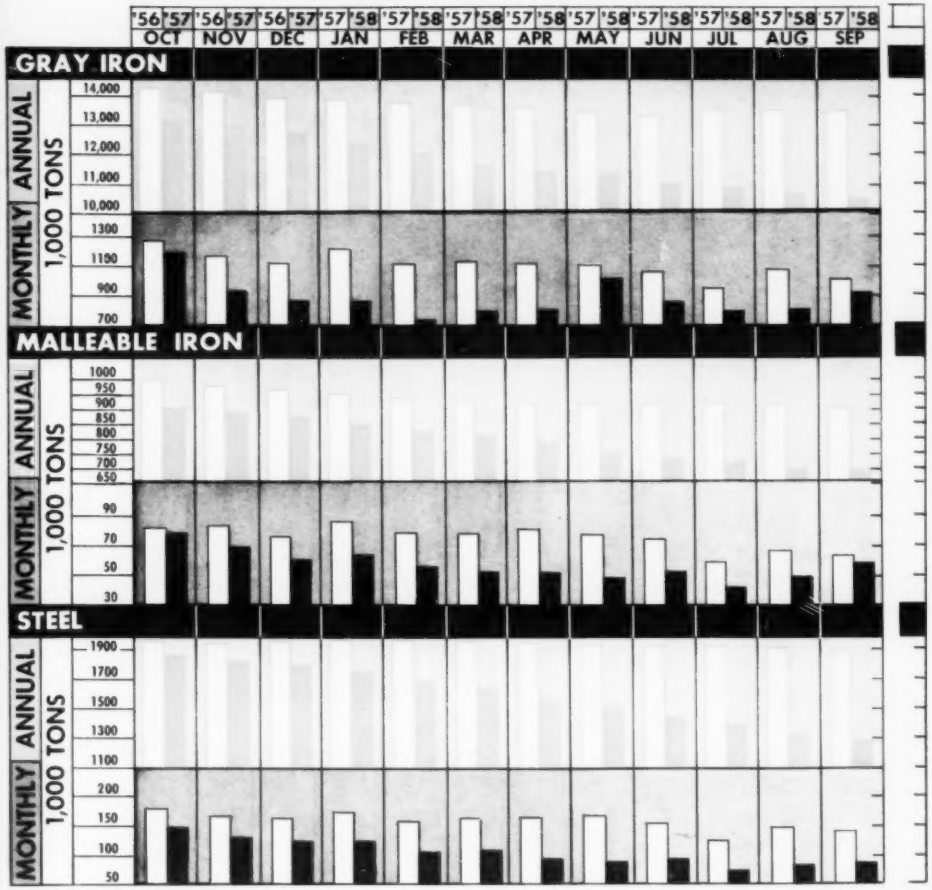
STERLING NATIONAL INDUSTRIES, Inc.
Founded 1904 as Sterling Wheelbarrow Co.
Milwaukee 14, Wisconsin, U. S. A.
Subsidiary Company: STERLING FOUNDRY SPECIALTIES LTD.
LONDON • BEDFORD • JARROW-on-TYNE, England

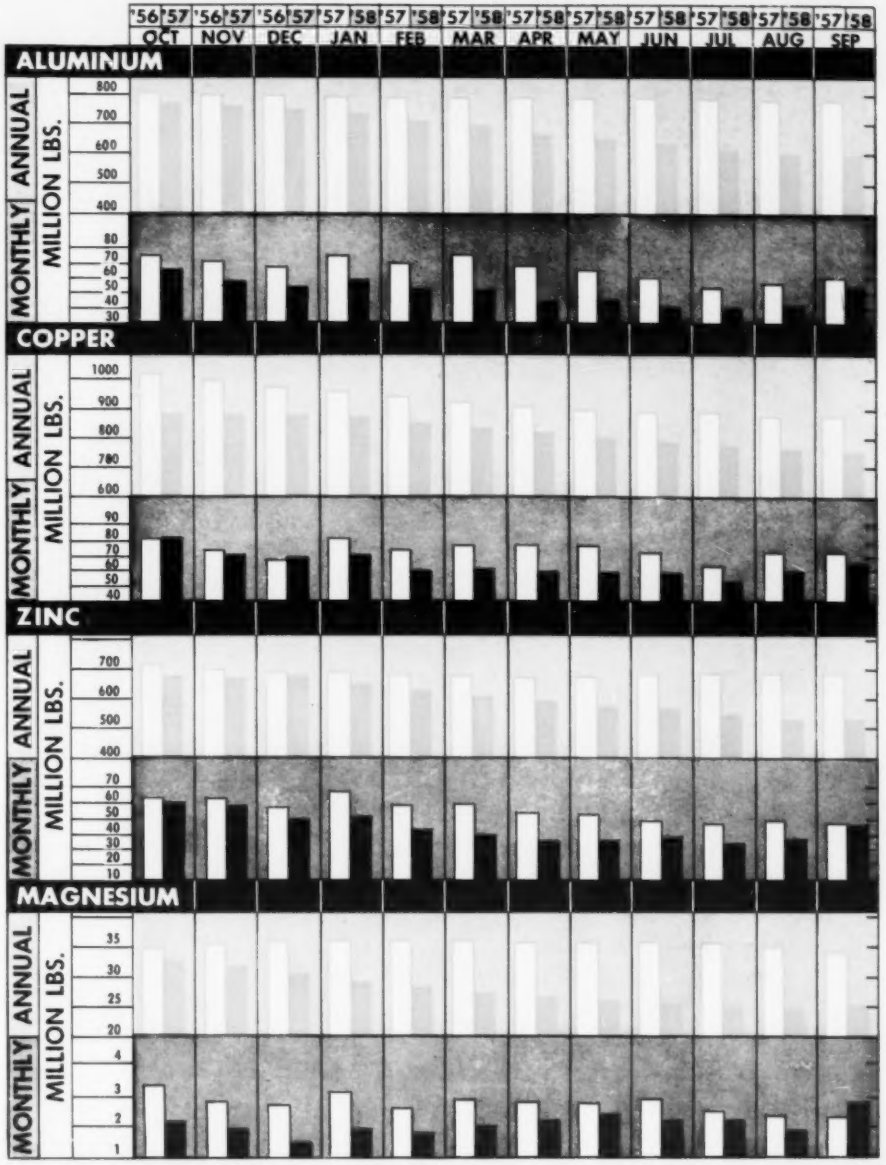
Sterling
WORLD WIDE SERVICE

Circle No. 244, Page 155-156

how's business . . .

The short and long term trend for metal castings shipments are presented here in bar chart form from statistics provided by the Bureau of Census, Department of Commerce. By examining the upper chart for each metal, you can see how the weight of castings shipped during a 12 month period has gradually declined since the period Nov. '55 – Oct. '56 (first bar on left of each chart). A reversal of this long range trend is leveling off as the result of a rebound from the low level of summer months activity. Compared with July and August shipments, September was again higher for all metal groups.

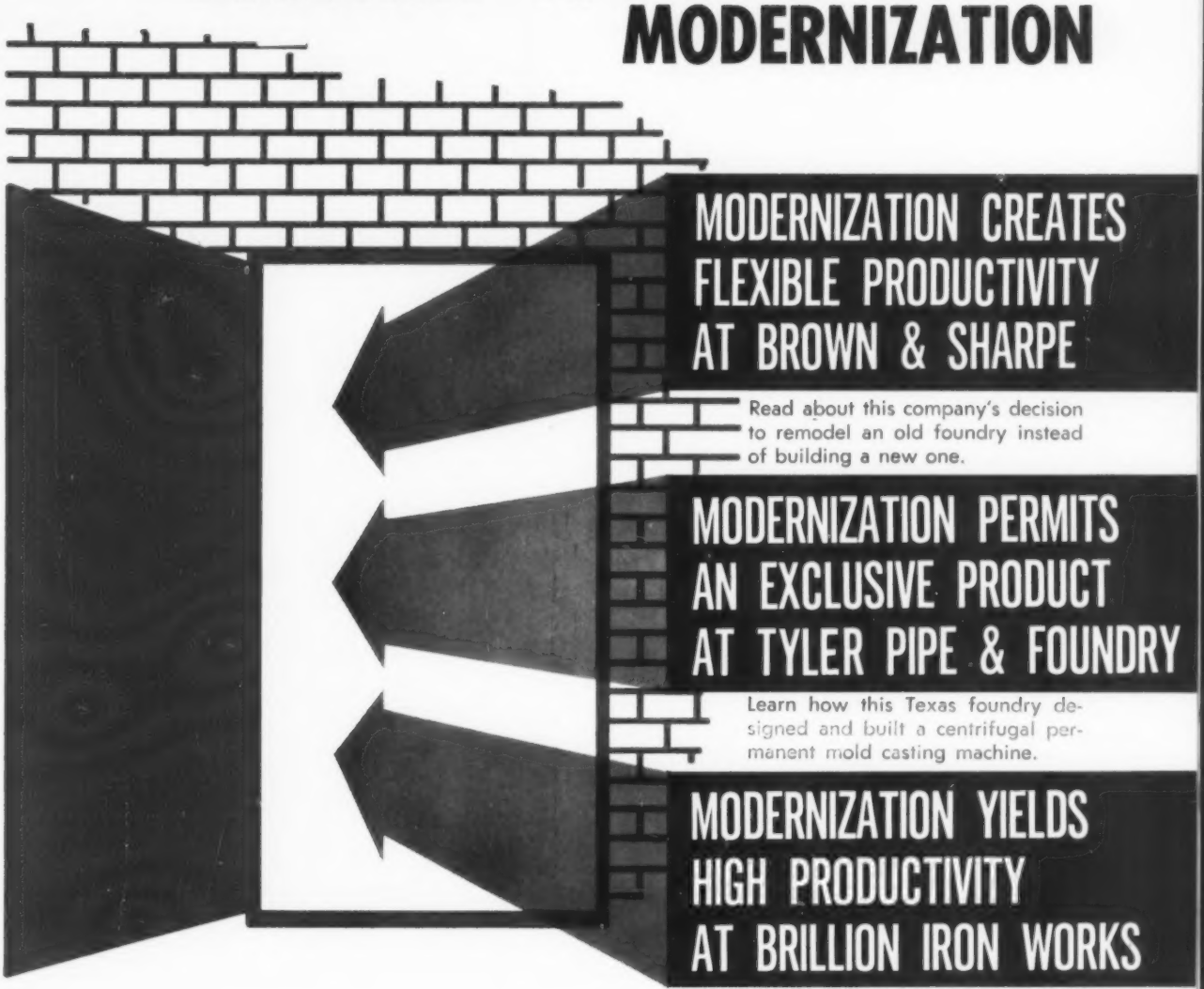



'56 '57 '56 '57 '56 '57 '57 '58 '57 '58 '57 '58 '57 '58 '57 '58 '57 '58 '57 '58 '57 '58
OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
ALUMINUM
MONTHLY ANNUAL MILLION LBS.
800 700 600 500 400
80 70 60 50 40 30
COPPER
MONTHLY ANNUAL MILLION LBS.
1000 900 800 780 600
90 80 70 60 50 40
ZINC
MONTHLY ANNUAL MILLION LBS.
700 600 500 400
70 60 50 40 30 20 10
MAGNESIUM
MONTHLY ANNUAL MILLION LBS.
35 30 25 20
4 3 2 1

Upper chart for each metal shows total shipments for 12 month period ending in year and month indicated. Example: In gray iron chart, last colored bar on right shows 10,400,000 tons shipped during period Oct. '57-Sept. '58 inclusive; adjacent white bar shows 13,400,000 tons for period year earlier, Oct. '56-Sept. '57.

Lower chart for each metal shows total shipments for each month in year indicated. Example: In gray iron chart, last black bar on right shows 920,000 tons shipped in Sept. '58 compared with white bar showing 1,000,000 tons in Sept. '57.

DOORWAY TO MODERNIZATION



MODERNIZATION CREATES FLEXIBLE PRODUCTIVITY AT BROWN & SHARPE

Read about this company's decision to remodel an old foundry instead of building a new one.

MODERNIZATION PERMITS AN EXCLUSIVE PRODUCT AT TYLER PIPE & FOUNDRY

Learn how this Texas foundry designed and built a centrifugal permanent mold casting machine.

MODERNIZATION YIELDS HIGH PRODUCTIVITY AT BRILLION IRON WORKS

Study this high-speed mold blowing installation for faster green sand mold production.

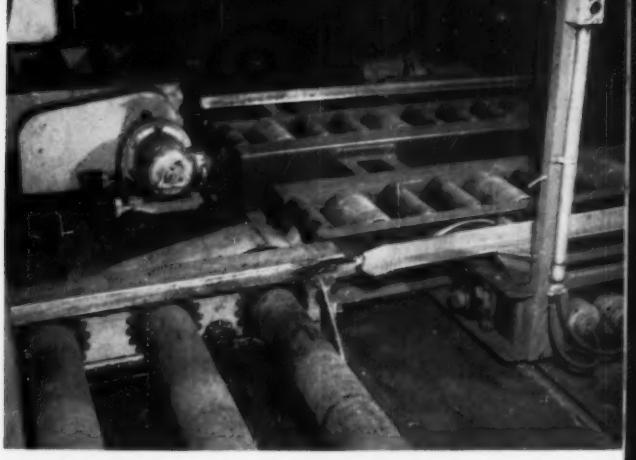
Step through this DOORWAY TO MODERNIZATION and you will see how three alert foundries have established their foothold in the future. Each of these foundries has recognized that modernization is the only successful cure for this nemesis—technological obsolescence.

These three foundries belong to a select group which is maintaining its competitive position against the encroachments of all other forms of metal fabrication. Modernization through mechanization and automation permits higher productivity . . . uses less floor space . . . reduces labor . . . yields more reliable uniform quality castings . . . leads to new markets.

If a lack of ready-cash is throttling your progress it may pay you to look into the possibilities of loan assistance from the Small Business Administration in Washington or equipment-leasing plans.

Now is the time to study the latest techniques, processes and equipment. Make a master plan, aiming for the ultimate needs of your foundry. Then take small steps in a well integrated sequence at the rate you can best afford.

MODERNIZATION CREATES FLEXIBLE PRODUCTIVITY AT BROWN & SHARPE



LEWIS W. GREENSLADE
Foundry Superintendent
Machine Tool Div.,
Brown & Sharpe Mfg. Co.
Providence, R.I.

Faced with the imminent problem of deciding whether to buy their castings, build a new foundry, or modernize an old one, Brown & Sharpe Mfg. Co., Providence, R. I., set up a three-step program to explore the best and cheapest way to procure or produce high quality castings.

FIRST STEP

As a first step, outside engineers were hired to survey company requirements. Their study was culminated with plans and costs for a new foundry capable of meeting production schedules.

SECOND STEP

Step number two was undertaken by a task group of Brown & Sharpe employees. Their job was to determine by investigation of economic factors involved whether Brown & Sharpe should: 1) purchase all its castings from one or more outside sources; or 2) make its castings in the proposed new foundry located within 50 miles of the main plant.

This group selected a representative group of castings and solicited by mail price quotations from a number of foundries with substantial capacity. Foundries that showed an interest were investigated, placing particular emphasis on the following factors:

1) quality of product
2) present available capacity
3) ability to expand and increase capacity to meet peak demands
4) lead time required to fill orders
5) ability to handle castings other than sample castings
6) cost accounting practices to insure realistic prices
7) financial position
8) general appearance of facilities and personnel.

Using data on this same sample group of castings, total casting costs were projected:

a) cost of castings in their own foundry,
b) as quoted by a satisfactory supplier,
c) as anticipated by a new foundry proposed by the outside engineering company.

Findings of Task Group

The team also visited companies buying all their castings to find out what problems they had encountered. Those who were buying their castings with a minimum of difficulty admitted that they had built up their vendors since depression days. They emphasized the difficulty of developing adequate sources of quality heavy casting.

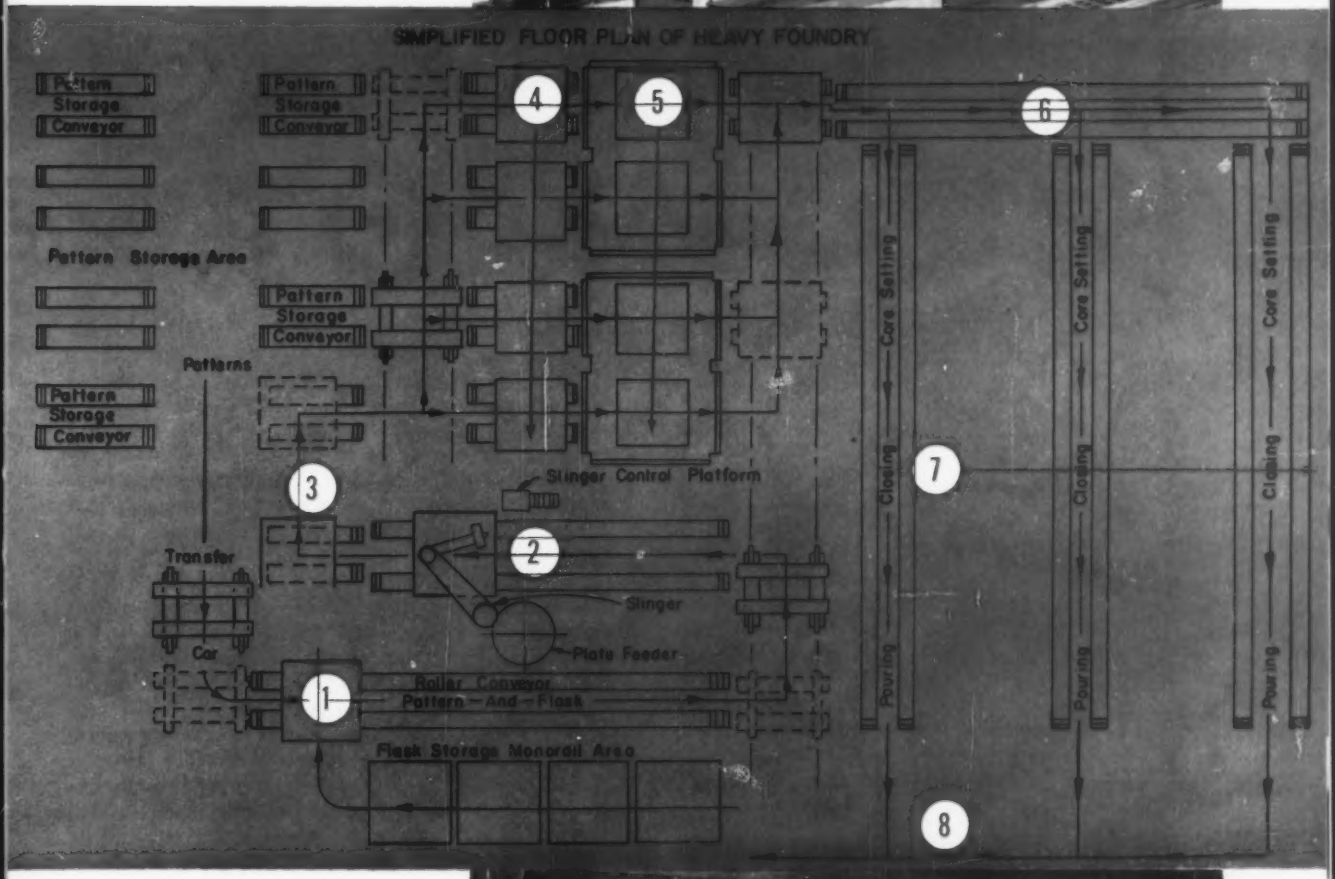
Of 25 foundries contacted, 19 were not interested, one gave no reply, three gave only partial quotations and only one gave a complete quotation. No quotation of the above group of foundries compared favorably with Brown & Sharpe's own cost.

Because potential sources of supply were extremely limited in number and capacity, and because average prices were higher than the Brown & Sharpe cost, the committee recommended that further consideration of subcontracting castings be abandoned.

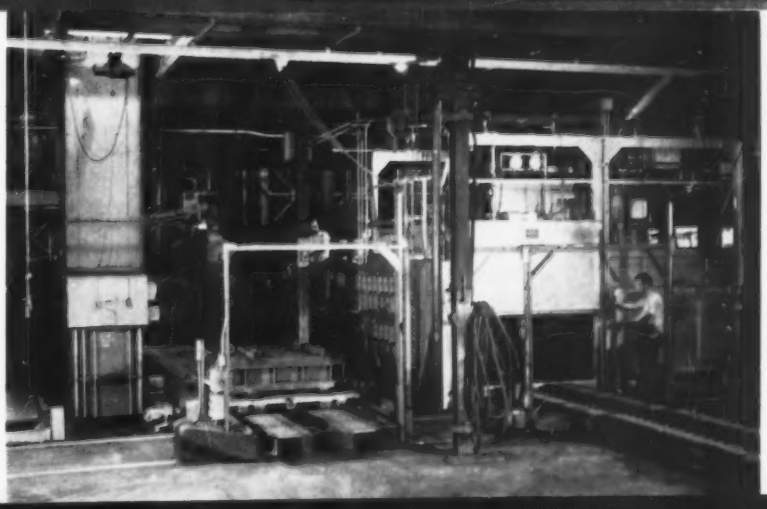
Considering casting requirements and the small rate of return on the large investment needed to build a new foundry, this plan was also abandoned. As an alternative the committee recommended that the pos-

The heart of the conveyor system is the transfer car (right) that shuttles between roller conveyors.

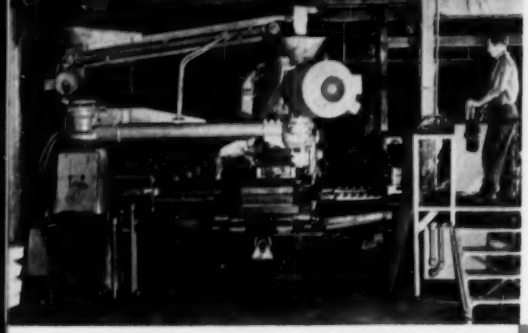
Station 3, patterns are removed and molds are touched-up at **Station 4** before going to oven for baking.



Station 1, pattern
Station 2, sand slinger
Station 3, rollover machine



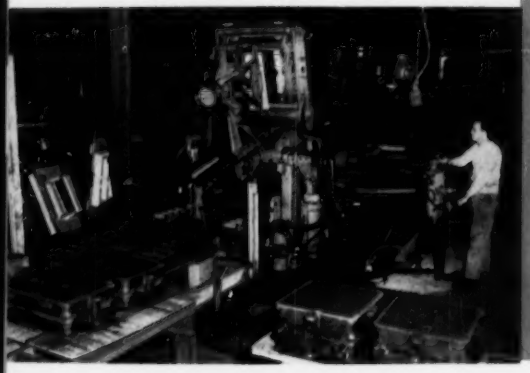
Flask is unloaded at **Station 2** as another transfer car waits for a baked mold to deliver to **Station 6.**

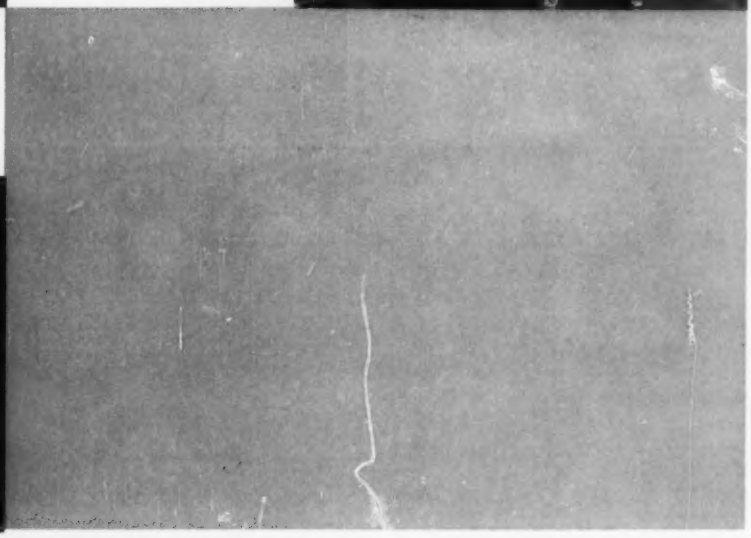


Roller conveyor that moves poured-off molds next to the shakeout operation.

Station 10, the sand slinger, and **Station 12,** rotating mold table.

Roll-over, pattern draw machine and transfer car which will move mold.





sibilities of rearranging and modernizing the present foundry facilities be investigated.

STEP THREE

The same committee was charged in the third step to make a further study of Brown & Sharpe's own foundry facilities with a view toward the possibility of incorporating new molding methods and material handling methods to increase the efficiency of the foundry, so as to realize a better return on money invested than in a new foundry.

It was determined that production methods did conform to modern practices. So anticipated savings would be due primarily to a reduction in man power attained by a rearrangement of operations and material handling rather than by a change in basic operating methods.

Because of the wide variety in size and shape of Brown & Sharpe castings and the low production requirements, our foundry must be termed a jobbing foundry. However, the committee felt that by rearranging and condensing operational areas, a better flow of materials could be obtained. This should give some of the advantages of a production foundry, including a reduction in cost.

The committee outlined a five-year program to bring about these savings without interruption to production schedules.

FIVE YEAR PROGRAM

Heavy Foundry Modernization

The first project in the five-year plan was the installation of a large unit capable of handling molds weighing up to 5 tons. By installing a loop, as shown in Fig. 1, divided into 8 stations, a different step in mold making and casting could be carried out at each station. Between stops, pieces are moved by a system of mechanical roller conveyor and transfer cars.

Station 1 Here molding starts with the flask being placed over the pattern. Assembly moves along by roller conveyor to a transfer car that picks it up and carries it to a second conveyor parallel to the first. By doubling back in the opposite direction toward station 2, a space saving, tightly coiled loop is created.

Station 2 Ramming sand into the flask is accomplished by a sand slinger, remotely controlled from a platform overlooking this station. The sand-slinger operator, by remote control, operates all conveyors and transfer cars to the machine. After the mold is rammed, it passes along the conveyor to the roll-over machine.

Station 3 Here the large capacity roll-over machine flips the mold over 180 degrees and the pattern is drawn from the mold. The mold then moves toward one of the finishing stations via a short conveyor and mechanized transfer car. The pattern is brought back and goes into the loop again or to the storage area.

Station 4 At the finishing station the molds are touched up, sprayed with a mold wash and readied for drying.

Station 5 Jet action gas ovens are used to dry the molds. Four of these ovens, side by side, can each dry an average mold in about 20 min.

Station 6 After the molds are baked, a transfer

car transports them to another conveyor which runs the length of the foundry. Here they can be stored until called for by push-button actuated by molders. Mold halves are delivered to one of three pouring lines where cores are set and molds closed, preparatory to pouring.

Station 7 After the metal is poured, castings are cooled overnight in the flask, eliminating the need for separate overnight storage area for flask, sand and castings.

Station 8 Next morning the molds go to the shaker on a schedule set up by the foreman so that the empty flask arrives at station 1 when needed. Flasks not scheduled for immediate use go to storage. The sand from the mold is returned to the sand conditioner unit and then to the slinger. Conveyors and elevators provide a smooth flow of sand all the way.

Modernization of Medium Work Unit

The second project in the over-all plan was the installation of a unit to produce medium-size castings. In this unit a rotating molding table is used to take the mold through the ramming cycle, using a slinger. Figure 6 shows the layout.

Flasks are put on the patterns at the first station; rammed by slinger at the second station; extra sand is struck off at the third station; and molds fed into a roll-over machine at station 4. From the roll-over machine they are placed on a power transfer car for distribution to the 5 closing lines. Molds are closed, poured and left overnight to cool on these lines.

The next morning molds travel by transfer car and power conveyor to the shakeout. Sand is processed through an automatic sand-conditioning unit and flasks returned to station 1 to begin another cycle.

Both of these units were developed with the thought in mind that, if production warranted, they could be run on a two-shift and possibly a three-shift schedule.

COREROOM

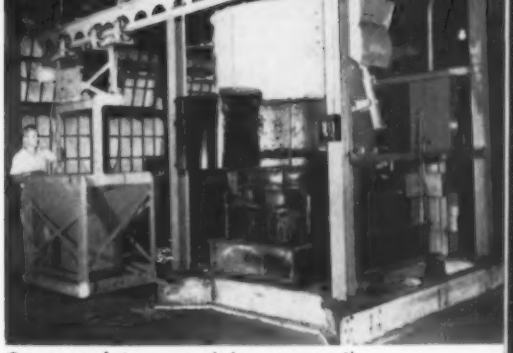
Third project in our plan was the rearranging of coreroom, installation of new ovens and a new sand-handling system.

Core ovens were placed in position, as shown in Fig. 10, so that an efficient work flow could be obtained without backtracking cores. All large and medium cores are made in the core manufacturing area and placed on cars which are handled by truck into the ovens for an 8-hour bake—Fig. 11. Baked cores are taken directly to the core assembly area and removed from the cars as needed. Empty cars are returned to the manufacturing area to be refilled.

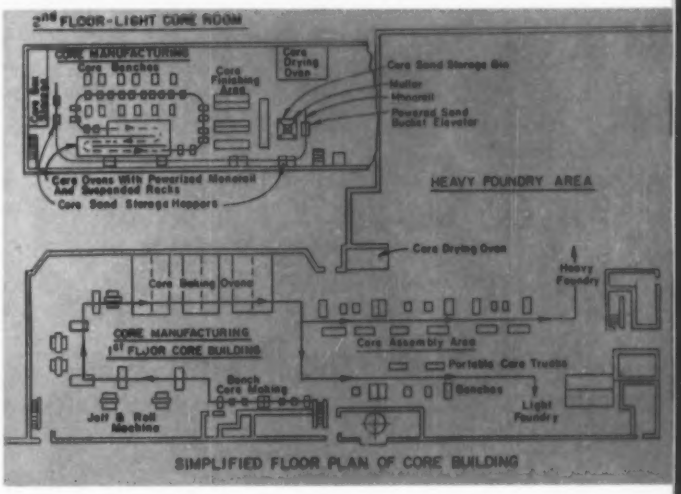
After cores are finished and dried in the core-drying ovens they travel by truck to the molders in the light and heavy foundries.

Core sand is mulled on the second floor. Bank sand is blown from the sand-storage area on the first floor to the sand-storage bin above the muller. Core oil is pumped to the muller from two 2000-gal tanks also located on the first floor. Dry binder feeds into the muller from a storage hopper above.

Mulled sand discharges into a powered sand bucket which rides on a monorail system and distributes sand to hoppers above the machines, benches and blowers on the main floor, (Fig. 12). Sand for the light core-making discharges from this same muller into bins which are taken to the benches by lift truck.



Core sand is moved by monorail.



SIMPLIFIED FLOOR PLAN OF CORE BUILDING

Small electric truck moves cores.

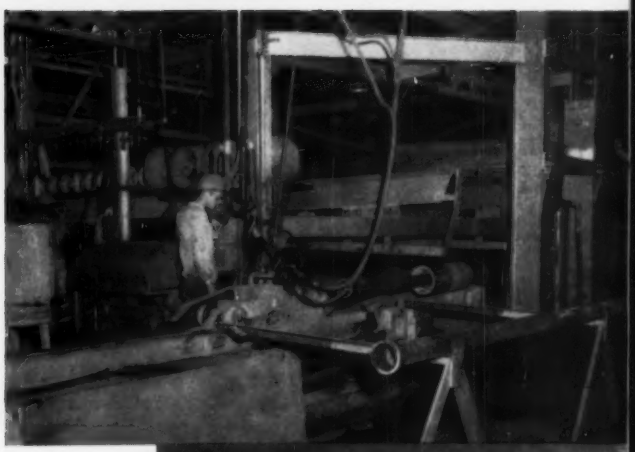
FUTURE PLANS

Our fourth and final step in this integrated program of modernization involves the relocating of our cleaning department. High efficiency will come from a straight-line flow of castings through cleaning operations via a monorail system.

Modernization at Brown & Sharpe is working proof of mechanized versatility. The three new departments were designed to adapt themselves efficiently to production needs—whether it be a torrent or a trickle.

MODERNIZATION PERMITS AN EXCLUSIVE PRODUCT AT TYLER PIPE & FOUNDRY

JACK H. SCHAUM / *Editor*



4 Hot iron pipe drawn out of the mold at stripping station just 20 seconds after pouring is complete.

The story of modernization through mechanization at Tyler Pipe & Foundry Company, Tyler, Texas, is not the story of a Lone Star. Instead, it is a story about a chain-reaction of enthusiastic team work that led to the building of the *first* centrifugal casting plant for 10-foot soil pipe in the United States. And it all happened in Texas. Well, no, not quite all. The story really got started when M. J. Henley, vice-president and general manager of Tyler Pipe, returned from a European tour of foundries. After seeing what was being done overseas Henley came back convinced that his creative team of engineers, foundrymen and craftsmen could build a single compact machine that would make soil pipe faster, better and with less labor than ever before in this country.

To improve the conventional, one must usually be un-conventional. So Tyler Pipe broke with tradition and designed their new equipment to:

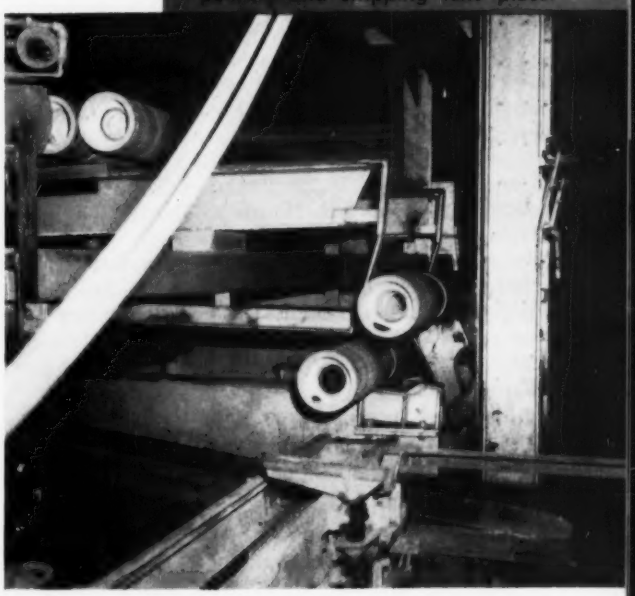
1) Make soil pipe 10 ft long instead of 5 ft.
2) Centrifugal cast instead of static cast.
3) Use permanent cast iron molds instead of sand molds.
4) Pour gray iron produced in basic water-cooled cupola instead of acid.

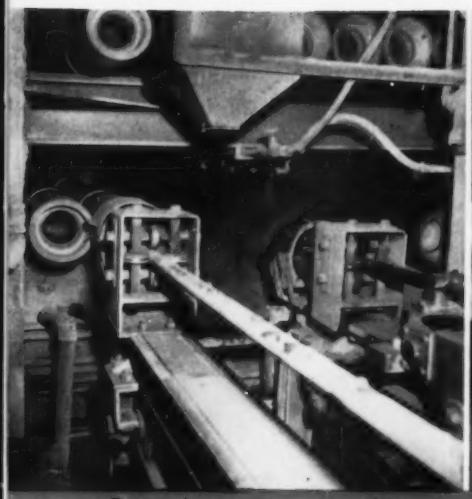
ADVANTAGES

1) By going to 10-ft pipe a $50 to $100 per ton savings is realized by the consumer in installation cost, since only one bell-joint is needed every 10 feet instead of two in the case of 5-ft pipe.

2 & 3) Centrifugal casting in permanent iron molds

5 Molds are lowered by hydraulic lift to the lower level rack where pouring and stripping take place.



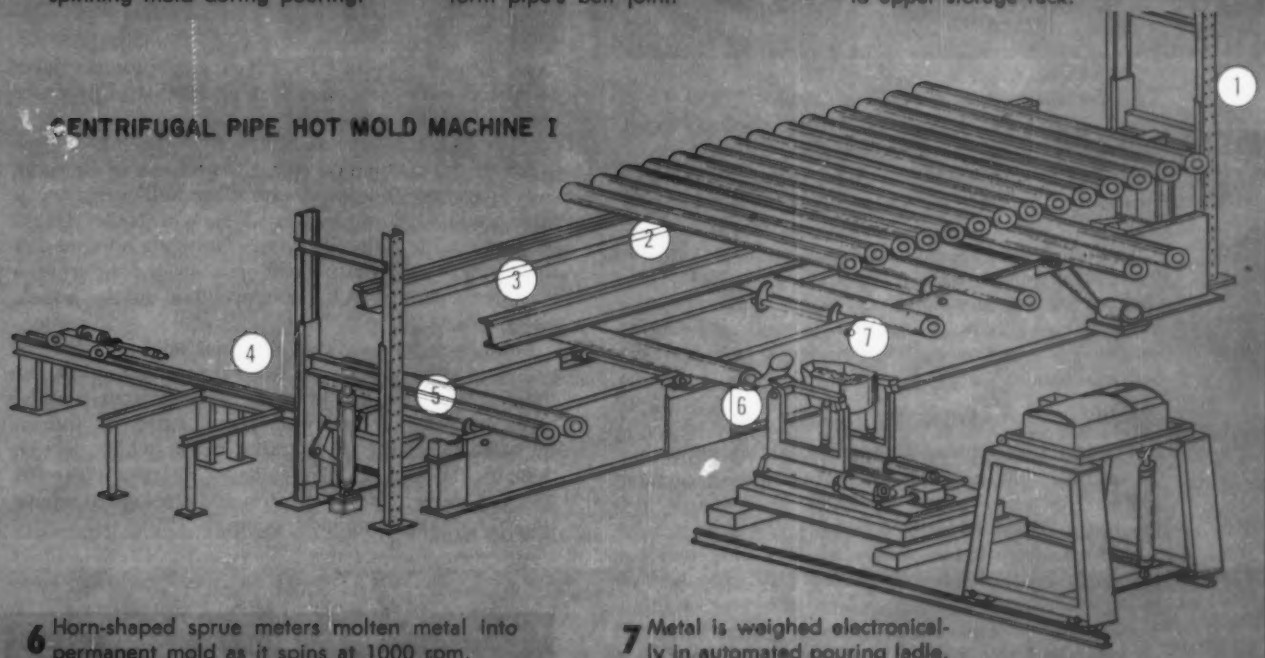


3 External water spray envelopes spinning mold during pouring.

2 Shell cores fit end of mold to form pipe's bell joint.

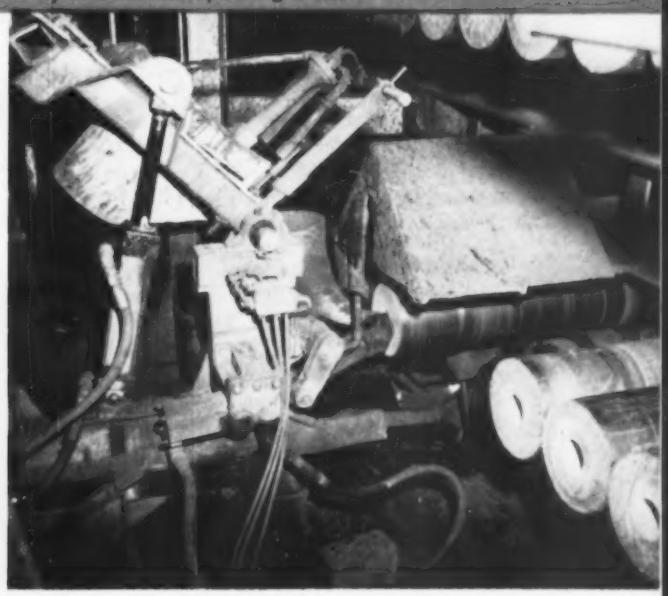
1 Hydraulic elevator raises molds to upper storage rack.

CENTRIFUGAL PIPE HOT MOLD MACHINE I



6 Horn-shaped sprue meters molten metal into permanent mold as it spins at 1000 rpm.

7 Metal is weighed electronically in automated pouring ladle.



gives cleaner surface, more uniform wall thickness, denser metal with higher physical properties, eliminates handling sand and flasks and yields faster production with less labor.

4) The basic water cooled cupola permits low cost high-sulphur raw materials to be used because it removes the sulphur and ultimately produces a low sulphur iron with excellent physical properties for soil pipe manufacture.

Under the direction of John Lasater, Chief Engineer; W. J. Speas, Jr., plants manager; John Warner, superintendent of foundries; and Sam Gibbons, superintendent of construction and maintenance, Henley's ideas soon progressed from the drafting board to blue prints to rigging shop to reality on the floor of the pipe foundry. Tyler Pipe believes in team effort so the final machine that is now spinning metal pipe 20 hours a day is a tribute to every man who contributed his skills to its creation. In spite of being an "original" it functioned almost perfectly from the very first trial run.

CENTRIFUGAL CASTING MACHINE

The machine, shown in Fig. 1, has an upper and lower rack that hold in all 35 cast iron permanent molds. For each pipe size—2, 3, 4, 5 and 6 in.—there is a complete set of 35 molds. Because of automated pouring, Tyler prefers to have only one size of molds in the machine during any one run, although it is possible to manufacture two sizes simultaneously. The upper rack is a storage rack that slopes so molds roll by gravity from entrance end to exit end. A hydraulic elevator at exit end lowers molds to lower level rack where pouring and stripping take place. Elevator at opposite end raises stripped mold to upper storage rack.

Before lowering to pouring rack the permold is cleaned out with an air blast and spray-coated with a slurry of diatomaceous earth. The mold rolls off elevator to first station on pouring rack where a shell core is placed in far end of pipe to form the bell-joint.

Pouring Operation

Mold then rolls to pouring station where it comes to rest on spinning mechanism. In a matter of seconds the mold is spinning at optimum speed—dependent on diameter of pipe being cast. For instance 4-in. pipe mold rotates at 1000 rpm. From a gas-fired holding ladle the exact quantity of molten iron is weighed by electronic load cell as it flows into the automated pouring ladle.

Pouring rate of metal into spinning mold is metered to give consistently reproducible quality on every pipe. (Fig. 4) A spray of water is directed on the spinning mold to maintain it within an optimum temperature range.

Then the mold rolls over to the stripping station where 20 seconds later the red hot pipe is smoothly drawn out of the mold with a hydraulic pulling mechanism (Fig. 5). Pipe rolls on to storage rack from which it is immediately transferred to coal tar dipping tank. Tyler uses the residual heat in the hot pipe, which is approximately 600 F., to keep the coal tar bath melted. Conventional external firing with gas or oil burner is thereby eliminated.

PRODUCTIVITY

The casting unit needs only four men to operate it—and one of them is a relief man. Of the other three men, No. 1 is positioned at the molten metal weighing and pouring station; No. 2 sets shell cores to form the bell joint; and No. 3 operates the mold-spraying operation. In the green sand molding department, 32 men turn out 1800 ft of 4-in. pipe per hour compared with three men making 1200 ft of pipe per hour on the new machine.

With 10-ft soil pipe spining out at the rate of two a minute for 20 hours a day, the problem of shipping can be serious. The pipes are often still warm when they are loaded onto railroad cars or trailer trucks waiting in the shipping yard. Only an hour earlier this same metal may have been in the form of a scrapped engine block being weighed in the cupola charge bucket.

Modernization of Tyler Pipe not only speeded the transformation of scrap to finished production but also the transportation of finished product from foundry to customers. The latter has been aided by the acquisition of a fleet of 45 trailer trucks which provide dependable, quick, door-to-door delivery service. Trucks return loaded with iron and steel scrap, alloys, limestone, spar, sand and binders.

M. Harvey

It would be an understatement to say that Michael Harvey, president of Tyler Pipe & Foundry, is proud of his modern pipe casting mill. In answer to the concern about unemployment resulting from labor-saving mechanization, Harvey replied, "Mechanization of manual operations at Tyler Pipe have always led ultimately to increased growth in plant employment. In 1954 we had only 430 employees. Today we have over 1160 on the payroll—and 40 of them are college graduates! Modernization through mechanization is the irresistable trend that characterizes our current climate for competitiveness."

MODERNIZATION YIELDS HIGH PRODUCTIVITY AT BRILLION IRON WORKS

JACK H. SCHAUM / *Editor*

Yes, modernization is for small foundries, too. Even for small-town foundries with big ideas like the Brillion Iron Works, Inc., Brillion, Wis. To prove it, this progressive foundry has just recently put into operation one of the FASTEST—240 molds per hour—MOST MECHANIZED AND AUTOMATED—5 employee—molding lines in the country.

Harrison Weaver, director of manufacturing, and Edward Schlies, plant engineer, started with nothing but two used mold blowing machines and a lot of determination to integrate them into an automated system. With the typical do-it-yourself climate that prevails at Brillion they utilized in-plant talent to build a slick running molding line that blows a green sand cope and drag every 15 seconds.

Brillion Iron Works divides its casting production between jobbing work for automotive industry and production for its own line of farm implements—rotary hoes, shredders, harvesters, pulverizers, seeders, silo unloaders and hay conditioners. The jobbing business consistently takes 85 to 90 per cent of the production. Regular and alloy grades of gray iron are produced in two No. 7 cupolas lined to 54 in. I. D. The new mold blowing line produces molds for clutch plates, gear blanks, wheel hubs, small flywheels and farm implement castings.

FLASK HANDLING

Well-engineered flasks are a must if you expect a mechanized automated system to run smoothly. The slightest deviation from norm can cause microswitches to trip prematurely, relays to miss actuation and flasks to jam in conveyor systems. To avoid this source of sabotage, Brillion poured its own sturdy cast iron flasks and precision machined faces, critical external dimensions, locating holes and pins. These custom-built flasks are all 18 in. x 18 in. with copes 5 in. deep and drags 4 in. deep.

A continuous molding loop has no beginning or end but we have to start somewhere. So lets begin with the conveyor that wraps this unit into a neat parcel. Empty flasks move along from shakeout to mold blowing, core setting, closing and pour-off on a conveyor system designed for simplicity and maintenance-free operation.

By closely examining Fig. 1 you can see the rubber V-belt drive which makes friction contact with a series of ball-bearing rollers. An electric motor is linked to the V-belt pulley system with a chain drive. Adjustable idlers are used to keep tension in the V-belt drives and thereby compensates for any stretching. In case of a jam-up anywhere along the line, powered rollers keep turning but can't exert enough forward drive to damage the flasks.

Copes and drags are still closed together, but are empty when they approach the molding area from shakeout. Cope flasks are automatically stripped from drags and conveyed to the cope blowing machine. Drag flasks continue on to the roll-over station. In Fig. 2 you can see the roll-over device in the process of flipping a flask 180 degrees in the vertical plane and simultaneously turning it 90 degrees in the horizontal plane. The inverted drag flask now moves off to the left on the upper roller conveyor.

MOLD BLOWING

Drag flasks approach the mold blower from the rear in Fig. 3. With flask conveyed into position in the molding machine, pattern plate rises from beneath, clamping flask up against the blow head. (Position shown in Fig. 3.) A muffled explosion of compressed air lasting less than a second signals the beginning and end of the operation that blows green sand into the mold. A sharp squeeze is exerted and then pattern plate drops down, leaving completed drag mold on roller conveyor.

Mold rolls out to position under roll-over station which can be seen in the process of operating in Fig. 3. Mechanism has gripped mold and is swinging through 180 degree arc that inverts mold and positions it for next move. A pneumatic ram then pushes mold onto powered roller conveyor. Note mold on conveyor in foreground. Resistance to indentation by strong thumb pressure on any part of the mold face demonstrates the uniform mold hardness of 85-90 developed by the blow-squeeze operation.

In the same picture you can see the overhead hopper for storing green sand that feeds this blower every 15 seconds. A belt-conveyorized sand system, completely independent from the rest of the foundry, returns the shakeout sand for reconditioning in a

muller and delivers it to the storage hopper mounted on top of mold blower.

Meanwhile, back at the cope blowing machine, essentially the same sequence of operations is taking place. However, no flask roll-over operations are required before or after blowing. In the foreground of Fig. 4 a cope flask has been moved from the cope blower to the mold conveyor by a robot transfer device. Completed drag molds can be seen rolling along at the lower level. If cores are used they are hand set as drag moves toward cope conveyor.

MOLD CLOSING

Copes are indexed into the closing station. Drags index into the lower level of the device, raise up and close into the cope. Cope conveyor opens and closed mold drops to a lower level (Fig. 5) where a pneumatic ram pushes the closed mold onto a short section of wheel conveyor. A transfer mechanism then picks up mold and sets it on pallet car conveyor.

The molds pass under a continuous chain monorail conveyor carrying weights that accurately descend on each mold. (Fig. 6.)

Weighting is immediately followed by manual pouring—a return to conventional reality where man still holds a slight edge on the robots of automation due to the variety of molds poured on this line. Poured molds proceed through cooling tunnel for 35 minutes cooling, then to shakeout. Flasks, separated at shakeout from their cargo of sand and iron castings, then start their next trip around this endless merry-go-round of production.

When running at peak efficiency the system contains 200 cope flasks and 220 drag flasks. Each flask makes a round trip from shakeout back to shakeout in 45 minutes.

This demonstration of modernization through mechanization is a tribute to the imaginative president of

Brillion Iron Works, Raymond D. Peters—a man who is always looking for new and better ways of improving his foundry operations. Says Peters, "This new automated mold-blowing line has increased our casting capacity by 25 per cent and at the same time reduced manpower requirements from 20 men down to five. This is one more improvement in a long line of continuing developments that have accounted for a 2400 per cent growth in Brillion sales since 1938."

Fig. 2 . . Rollover flips and turns flask.

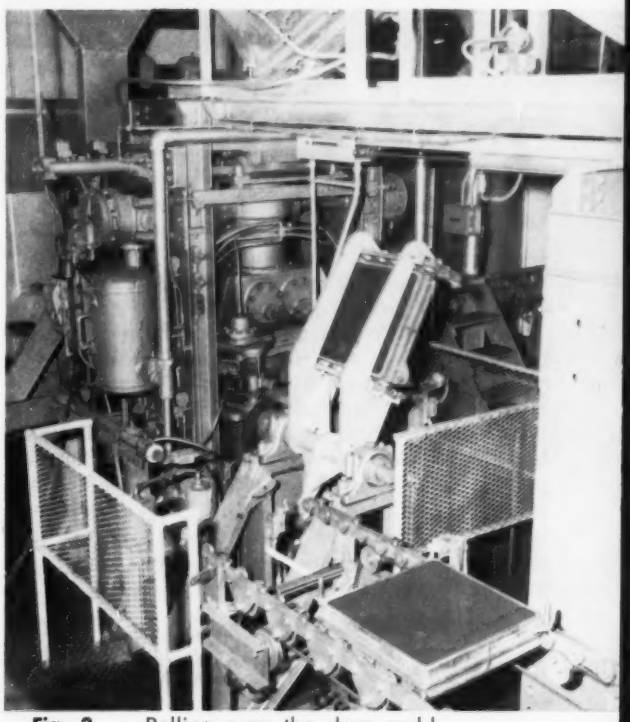


Fig. 3 . . Rolling over the drag mold.

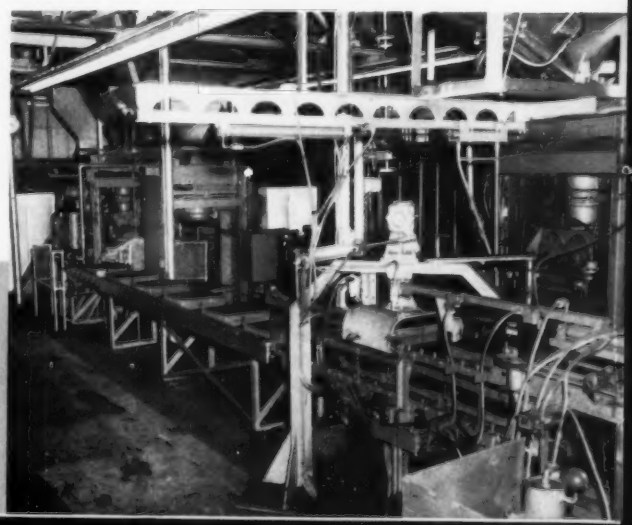


Fig. 4 . . Cope flask (foreground) has been removed from blower. Completed drag molds are moving on lower level.

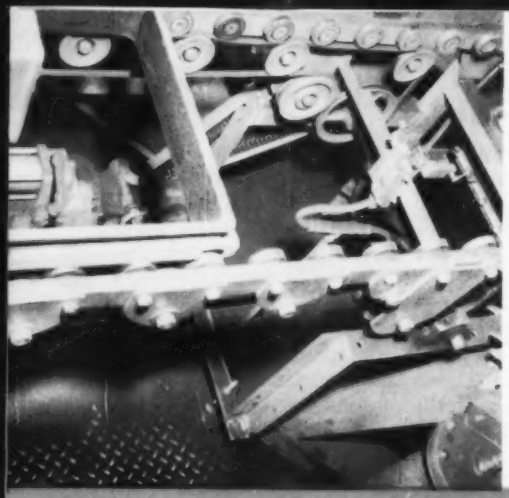
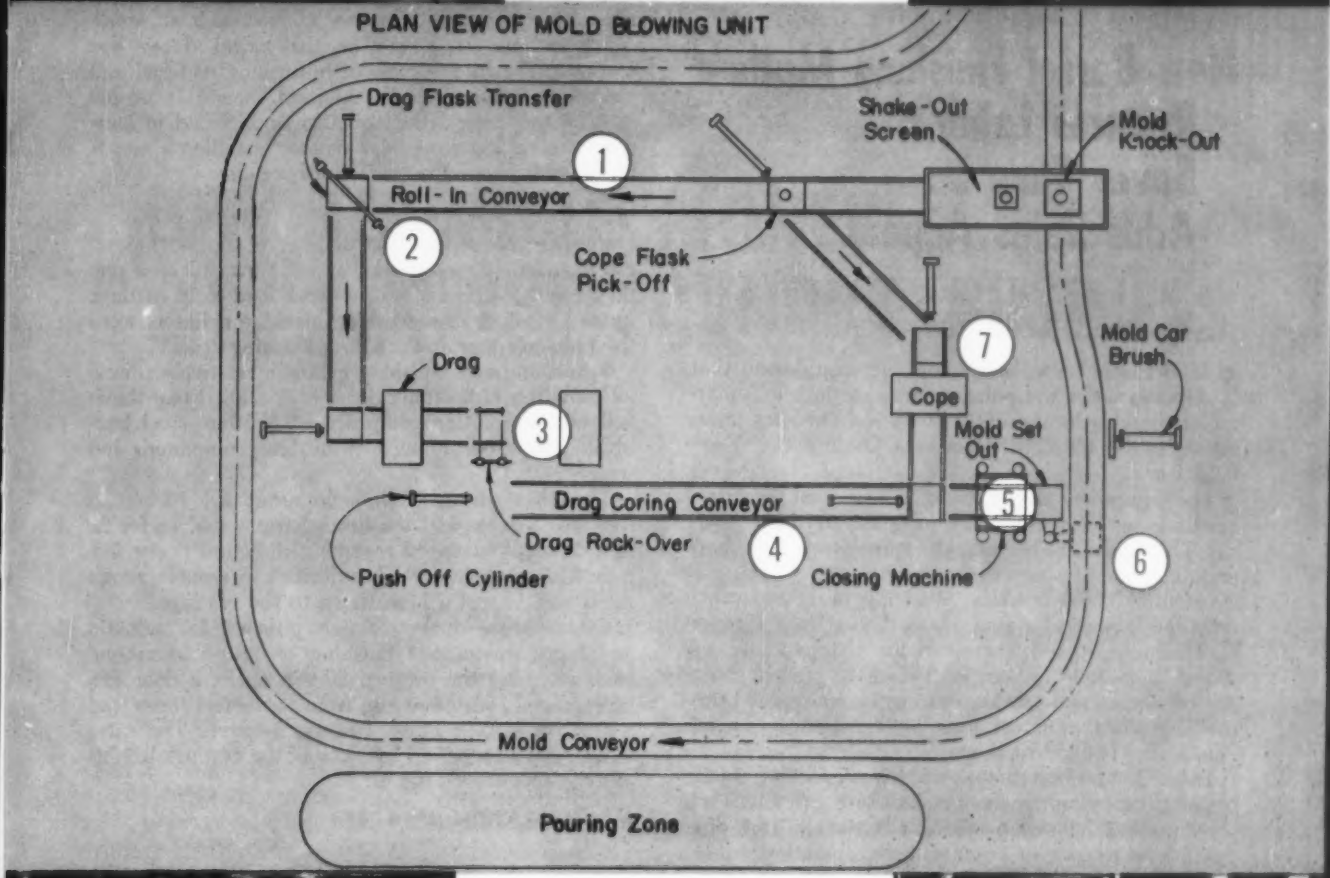


Fig. 1 . . V-belt drive applies power to mold-conveyor rollers.

Fig. 7 . . Blower produces copes at rate of one every 15 seconds.



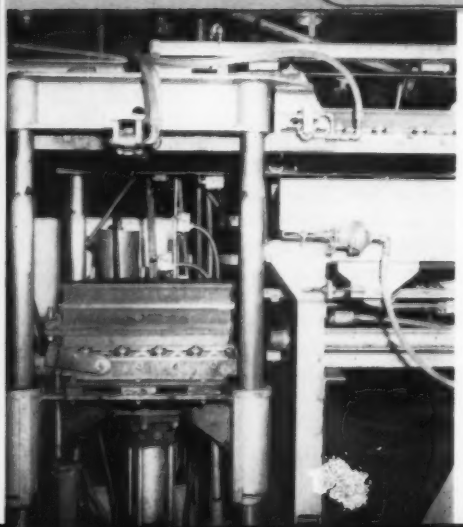
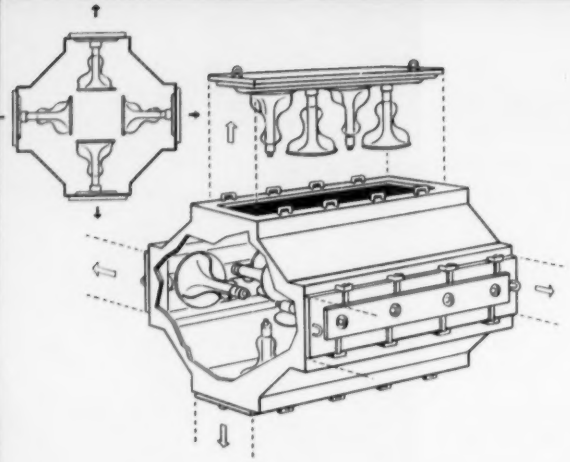


Fig. 6 . . Mold weights are carried and placed by overhead conveyor.

Fig. 5 . . Closed mold is pushed onto wheel conveyor for transfer.



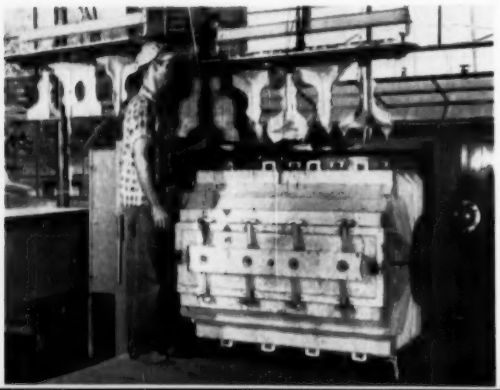
New Barrel Finishing Method Reduces Labor . Saves Time . . Adds Sales Appeal . . .

Modernized new barrel-finishing equipment that removes burrs and polishes large castings in a matter of minutes has recently improved finishing operations at the Fairfield Aluminum Casting Co., Fairfield, Iowa.

The equipment uses fixtures to hold cast washing-machine agitators in place during the finishing process. The barrel finisher quickly removes all "fins" and imparts a smooth sheen to the castings.

"Fixture barrel finishing is saving us considerable time and labor and aiding our customer, too," George H. Hammon, superintendent of the Fairfield foundry states. "Smoother agitator surfaces help prevent damage to clothes and fabrics, our customers report. Also the burnished agitators look better. This improved appearance helps close the sale."

Before fixture barrel equipment was installed, washing machine agitators were machine finished only. This slow process left many sharp edges that were impossible to remove in the machining operation. Much hand labor was required before the casting could be shipped.



HOLDING FIXTURES

After investigating various barrel-finishing techniques it appeared that the rough castings needed fixtures of some type to prevent them from striking each other during the tumbling action. Standard barrel finishing methods permit castings to slide freely with the finishing compounds and media. Special fixtures are a new development which holds castings stationary inside the drum barrel. Fixtures are particularly important when castings have sharp surface contours, large, flat areas and intricate shapes.

Many types of holding devices were available for the Fairfield washing machine agitators. Holding bars were selected as the device best suited for keeping the washing machine agitators firmly in place yet permitting burnishing compounds to reach all areas.

Right angle mounting on the barrel doors was chosen to permit free-flow of burnishing material and facilitate handling. Door mounting made it simple to load and unload the agitators, too. Speed in handling the castings was increased by installing a monorail directly above the barrel finishing unit.

Quick Door Changing

In order to increase the number of agitators processed, a four door model was used instead of a one door type. This increased the work load to 16 castings instead of nine. Four washing machine agitators were fixed to each door on the fixture finishing drum.

Burnishing and polishing is now a relatively simple job. The barrel finishing drum is first filled two-thirds full with a solution composed of 3/16-in. steel burnishing balls, two types of burnishing compounds and water.

The 16 washing machine agitators are locked in the door fixtures and the drum barrel revolves for 20 min at medium speed reversing direction every five min. This time interval is sufficient to remove rough burrs and impart a high sheen to the castings.

Extra fixture doors make it possible to maintain an almost continuous finishing of rough aluminum castings. After the original 20-min cycle, a door can be removed every five min from the barrel drum and a new set of four rough castings inserted. The extra finishing time received by some of the castings brightens the sheen even more.

MODERNIZATION PAYS-OFF

This continuous cycle of work permits 225 finished castings a day to be produced—high quality washing-machine agitators that can be sent to the customer without additional cleaning. The only time loss is the 45 second interval between loading and unloading door fixtures. Flushing and recharging the barrel with a new solution is kept to the minimum since the original solution can be reused several times.

The drum barrel quickly converts for either "loose" or standard fixture finishing by removing the steel plates and inserting rubber plugs in the bolt holes.

This versatility permits a wide variety of abrasive chips, hardened steel shapes and finishing compounds to be used. The equipment can efficiently debur, grind, polish, burnish, reduce surface porosity, form radii, descale, degrease and perform many other functions as required.

DONALD E. BRITTON /
Britton and Associates
Northbrook, Ill.

HOW TO MAKE MONEY IN THE FOUNDRY BUSINESS

This article is aimed at you foundrymen who employ twenty, thirty, fifty, up to, say, two-hundred-and-fifty men in your shops. This size group comprises 94 per cent of the foundries in this country. The article discusses management systems and management controls. It will tell you something about managing a small business with big business methods. And it talks about a gold mine and the game of golf.

We all know it's no cinch to make money in the foundry business. But there's an excellent approach to the profit problem that will give you much better than a fifty-fifty chance to stay in the black—even if you're down to a three-day week.

Chances are you have a gold mine locked up right in your own filing cabinets. This treasure isn't in the form of gold, however. This gold is in the form of facts, figures and ideas. And it can be tapped and put to work easily.

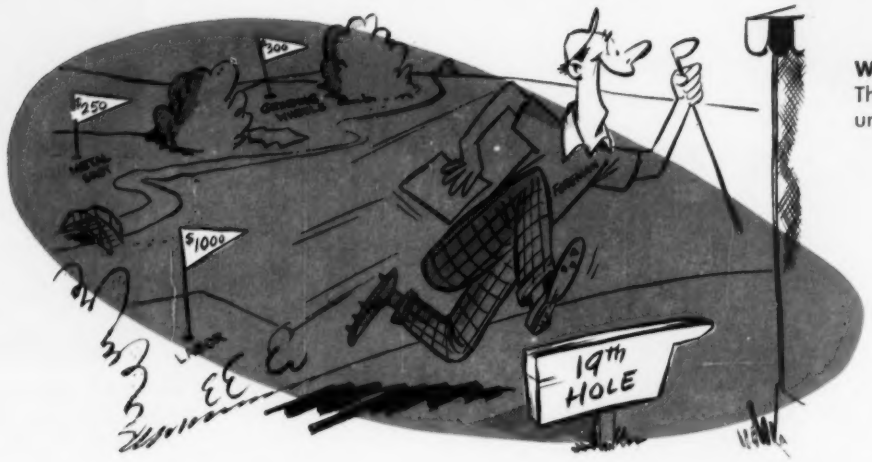
It's a good bet that you spend a minimum of $5000 a year collecting, recording and storing statistical data on your foundry operations. If you have as many as three persons in your accounting and cost section, you spend nearly $20,000 a year collecting, recording and storing statistical data.

For every year you have been in business you have collected, recorded and stored $20,000 worth of statistical data. If you have been in business since World War II, you have collected, recorded and stored a quarter of a million dollars worth of statistical data. All you have to do now is go to work and refine this mass of statistical ore into pure gold. *This is a surprisingly simple thing to do.*

COMMUNICATION

The key word which will become the secret of your newfound success is communications. This word will unlock the gold supply. This communication refers to the kind that transmits ideas, facts and figures from one individual to another; from your foreman to your plant superintendent; from your accountant to your board chairman; and from your filing cabinet to your management team. In other words get the statistics out of the files and into use.

First, you will have to understand what this information is that you're going to uncover and pass around. So take all of the statistics that you have collected, recorded and stored for the last five years, or ten if possible . . . the more the merrier . . . and



We did it, Boss, we did it! The Cleaning Room stayed under par on every job!

dump them into the lap of a good numbers man (accountant to you). Ask him to go off in a corner some place for a couple of days and grind up all this data in your biggest muller. Then ask him to riddle all of it out onto the floor. And then ram it all up in just such a way that he puts together for each month and each year a standard operating cost for every expense classification in your general accounting and cost accounting ledgers.

Furthermore, ask him to do it in just such a manner that he will be able to tell you or any other member of your management team what that monthly or yearly standard operating cost might be at any level of business activity from 25 per cent to 125 per cent of your standard capacity.

All right, now let's go over that again keeping in mind that there is really nothing difficult about this gold mining project and that it will pay off.

STANDARD COSTS

We were talking about expense classifications. Let's take, for example, abrasives. In this account your statistics man will add together all of your purchases of grinding wheels, shot, grit, sanding belts, cut-off wheels, band-saw blades and tumbling stars that you use in the cleaning room. He will come up with a total amount of money expended for these materials for each of the last ten years. Alongside each one of these figures he will place the total volume of sales for each year respectively.

He will then compute the ratio between these two figures: that is, the percentage of abrasives expense to the sales volume. (Of course, computing the ratio by using the number of pounds of castings shipped instead of sales volume may provide a more accurate figure in some expense catagories.) He will notice that these two groups of figures correlate. The percentage for every year is almost the same. Let's say, for purposes of illustration, that most of the percentage computations hover right around 3.5 per cent. This means that for every thousand dollars of sales, you spent $35 for abrasives.

When the dollar volume of sales was up in any one year, the dollar amount expended for abrasives was up accordingly. When the dollar volume of sales was down, the dollar amount expended for abrasives was down accordingly. But the percentage figure remains almost the same. One year it might have got up to 4.1 per cent and one year it might have got down to 2.9 per cent. Let's assume that these were the maximum and minimum figures. Unless there were special circumstances like an unusually low price for abrasive materials the year you experienced the low figure, or that your shop ran a predominantly different type of work requiring less cleaning effort, this low point is your best score.

If you can operate the cleaning room at that peak of efficiency one year, you should be able to operate it that well all of the other years, if you work at it. So you will set your standard cost of abrasives at 2.9 per cent of your sales volume. For the purpose of measuring the efficiency of your future operations, you will apply this percentage factor each month to your abrasive consumption. If current operations match up well with this standard, you can give your cleaning room foreman a pat on the back and maybe an extra buck or two. If current operations show up poorly against the standard, you can give the cleaning room foreman the needle.

VARIABLE EXPENSES

You will find that not all of your expenses vary directly with the increase or decrease in your volume of sales as do abrasives, direct materials, direct labor and others. These latter expenses are called *variable expenses.* Some expenses like building insurance and depreciation expenses are always the same whether you operate the plant or not. These are called *fixed expenses* and do not require close supervision, only periodic review. But some expenses are partly fixed and partly variable, like office salaries or maintenance expense. These expenses are called *semi-fixed expenses.*

It takes a little more voodooism to set standards for these expenses for all levels of production. The standard in this case must be computed in a manner which will enable you to find readily the standard level for any semi-fixed expense for any production level from 25 per cent of standard capacity to 125 per cent of standard capacity. This can best be done by plotting on a chart semi-fixed expenses for as many months of operational history as you are able to dig out of your files.

Plot the total amount expended for maintenance, for instance, plot monthly against the total production (or sales adjusted for inventory variations) each

month. This plot will produce a curve which will then become your chart of standard expenditures for any level of production activity. The plotted points will probably run all over the sheet, but you will notice a definite trend out to the right on the plot and sharply up as production increases. Draw in an optimum curve through all of these points. This drawn curve, then, becomes a line of points representing what your maintenance costs should be from low production at the left on the chart to capacity production at the right of the chart.

Controlling More Closely

Your expense classifications may be refined to any desirable degree. For instance, in the illustration above concerning abrasives, your cleaning room foreman could set up his own standards for the materials within his control. He can break down this all-inclusive account into separate accounts and standards for wheels, shot, grit belts, saws, etc., and thereby keep an extremely sharp watch on all the supplies he uses.

And certainly you will wish to make such refinements when an expense gets out of hand. You'll break it down under analysis to determine if a particular run of castings required an excessive consumption of abrasives for a week or so during the month, for instance, before berating the foreman for a bad showing. And you'll examine your job cost records for detailed explanations of irregularities.

If you do not have a job cost system and a departmental cost system of some kind underway, you must get started on such a program immediately. It is suicidal to attempt to operate a foundry without costing of some kind. Anyway, the point to be made here is that wherever your current operations meet the standard, you need not concern yourself further about them. But wherever they do not meet the standmeet the standard, you will dig and dig until you lick the problem.

USING STANDARDS

Let's get back to our mining venture. Here is what you are about to accomplish. The analysis of your historical data provides you with a priceless set of standards for every type of expenditure from direct labor to postage. These tables will enable you to compare in a matter of minutes *what you are doing* in every corner of your shop today, this week, this

month, this year with *what you should be doing* in every corner of your shop today, this week, this month, this year.

There are some side benefits lying around in this program, too. Group incentives become easily workable. And, for instance, when all of your boys in the cleaning room get an extra buck or two because they made the standard, they're not as apt to run off with your tools and supplies as they do now . . . or let their buddies do it either . . . because they know they won't make the standard if they do. Many's the home workshop that has been outfitted with your tools, perhaps you know.

Speaking of golf, good steady winners at golf don't play against the other members of the tournament. Good steady winners play against par. Par is standard for the course. If you always shoot par, you win.

All of the data your numbers boy fixes up for you tells you what par is for your foundry operations. He has given you a way to measure everything you do against the standard for it. If you equal or surpass the standard all the way down the line, you win.

MANAGEMENT INFLUENCES

Of course, as was mentioned before, there's another little trick to this whole business. This trick is the big "if" in today's profit equation. It's called MANAGEMENT. The quality of management is the only variable in the profit equation. Your competitors buy materials and supplies from the same markets; hire a labor force from the same labor pool; bear the same costs of manufacturing; borrow from the same

The old pros know that consistent par-shooting has its rewards at the end of the tournament.

banks; suffer the same taxes; sell to the same customers. The one great unknown in this profit equation is the technique of putting all of these factors together.

The way in which you use the statistical data you have worked up into a set of standards; the way in which you have organized the communications of these standards throughout your management team; the way in which you require an on-the-spot performance measurement of everything you do in your shop against these standards; and the way in which you get the deficiencies corrected is the measure of your ability as a manager. In other words, if you find out where you and your boys don't measure up, and work on those weaknesses almost to the exclusion of all else until you do measure up, you'll win.

BUDGETS

Lastly, let's talk about budgets. A budget is a controlled plan for the future. Your newly created set of tables and charts enables you to work out an effective operating budget so easily that you can do it with one hand buried in a sand heap. As a matter of fact, this set of standards is a flexible budget for all expenses as well as a device for measuring performance. All that you need to add to the information contained in your set of standards is your program for CAPITAL EXPENDITURES.

Capital expenditures are monies spent for new machinery and equipment, new buildings, pattern equipment, and, for budget purposes, promotional outlays and professional fees.

What we have been talking about throughout this entire article is devising a means to *control all of your cash disbursements.* You can control operating expenses by matching them against the standards you have set up out of the data you have collected in your filing cabinet. You can control capital expenditures by setting up a budget for each quarter which places a limit on equipment purchases and professional services outlays. This limit will be set in accordance with how much cash you will have after you have covered all of your operating expenses.

You will know exactly what your cash position will be during the entire budget period because: 1) you have figured out from past records and your business barometer just about exactly how much your sales volume will be; 2) you know precisely what your operating expenses will be at this production level; and 3) sales minus expenses leaves X number of dollars to spend for new equipment, promotions and dividend checks. If you are a good manager, you can't miss.

PROFIT

If this idea is so simple and so slick, why hasn't it been done before? It has been. Big business operates this way. Big business has operated this way for decades. *That's how big business got to be big business.*

When you have refined that $250,000 worth of gold in your filing cabinet, invest it in a measurement system . . . a communications system . . . a management system. You will earn a return on the $250,000 at a rate of more than 10 per cent per annum.

You'll be filthy rich!

1959 CASTINGS CONGRESS PAPERS

■ The technical articles appearing in this preview section of MODERN CASTINGS are the official 1959 AFS Castings Congress papers—the most authoritative technical information available to the metalcasting industry.

Nearly 100 technical papers scheduled for presentation at the 63d Castings Congress of the American Foundrymen's Society at Chicago, April 13-17, 1959, will first be officially preprinted here.

■ Readers planning to participate in oral discussion of these papers during the 63d Castings Congress are advised to bring them to the technical sessions for ready reference.

■ Written discussion of these papers is welcomed and will be included in the publication of the 1959 AFS TRANSACTIONS. Discussions should be submitted to the Technical Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.

FOUNDRIES CAN PRODUCE THEIR OWN CAST IRON DIRECTLY FROM ORE

By H. W. Lownie, Jr. and A. J. Stone

ABSTRACT

Foundries might increase their profits by using some recently developed direct-reduction processes for producing their iron. Some of these processes are suitable for integration into a foundry to replace the conventional cupola facilities and other melting auxiliaries. Under some conditions which exist in iron foundries today, these processes can be used to produce and melt iron more cheaply than by the present conventional methods. The use of direct-reduction processes would also reduce the foundry's dependence on outside sources of pig iron, scrap and coke.

The background of direct-reduction processes is given. Typical processes are described, and their advantages and disadvantages are discussed. Costs of producing iron by direct-reduction are summarized, and are compared with those involved in melting in a cupola.

DEVELOPMENT OF DIRECT-REDUCTION PROCESSES FOR IRON ORE

Recently developed processes for making iron from ore offer to foundries melting 100 tons of iron or more per day the opportunity to reduce their cost of iron and their dependence on outside sources of pig iron and scrap. This paper describes general aspects of these processes and shows how the processes could fit into foundry operations.

The blast furnace has been for many years (and still is) the only commercially important producer of pig iron in the United States. Huge blast furnaces today produce pig iron for about $38 or $40 per gross ton.

Continuing growth in the number and total output of pig iron blast furnaces, however, requires the solution of a number of problems which have been arising to plague the operators of blast furnaces.

A new blast furnace must produce about 1,200 tons or more of iron per day to be competitive with existing furnaces. The furnace and its auxiliaries, including coke ovens, would cost about $40,000,000.

High-quality coke is as important to the operation of blast furnaces as it is to the operation of cupolas. Blast furnaces consumed about 69,000,000 tons of metallurgical coke in 1957 as compared to an estimated 2,500,000 tons in cupolas. Large amounts of relatively scarce coking coal are required for this coke. The diminishing supply of good coking coals has necessitated large investments for improved methods of mining, treating and blending coals.

In 1957, over one quarter of the iron ores used in the United States were imported because domestic direct-shipping (unbeneficiated) ores are being rapidly depleted. Expensive plants for the beneficiation of taconites and other ores low in iron content have been installed to assure future supplies of domestic ores.

Everything associated with the blast furnace, therefore, must be on a very large scale for economical operation. The need for units that can produce iron economically in smaller quantities using poorly coking coals has been the driving force behind the development of other reduction processes.

Although the term is neither properly descriptive nor accurate, these nonblast furnace processes today are being called "direct-reduction" processes. This paper discusses the use of direct-reduction processes in foundries. When using such a process the foundry would receive iron ore, not pig iron, as a raw material.

FOUNDRY PROBLEMS BACKGROUND IN THE MELTING OF IRON

In order to analyze the probable value of direct-reduction processes to the foundryman, the cost of producing molten iron of the desired composition ready for pouring into molds should be known for both conventional methods and direct-reduction methods. For the conventional cupola operation, a foundry can be expected to pay (in mid-1958) about $40 to $60 per ton for its metal charge (exclusive of alloys). Melting costs (conversion costs) including labor, coke, maintenance of equipment, depreciation of capital equipment and overhead can add another $15 to $50 per ton (depending upon the type of foundry and tonnage melted).

Thus, the cost of molten iron in the ladle is about $55 to $110 per ton by conventional cupola methods. If iron of the same composition and temperature might be produced by another method at lower cost, progressive foundries should be familiar with the

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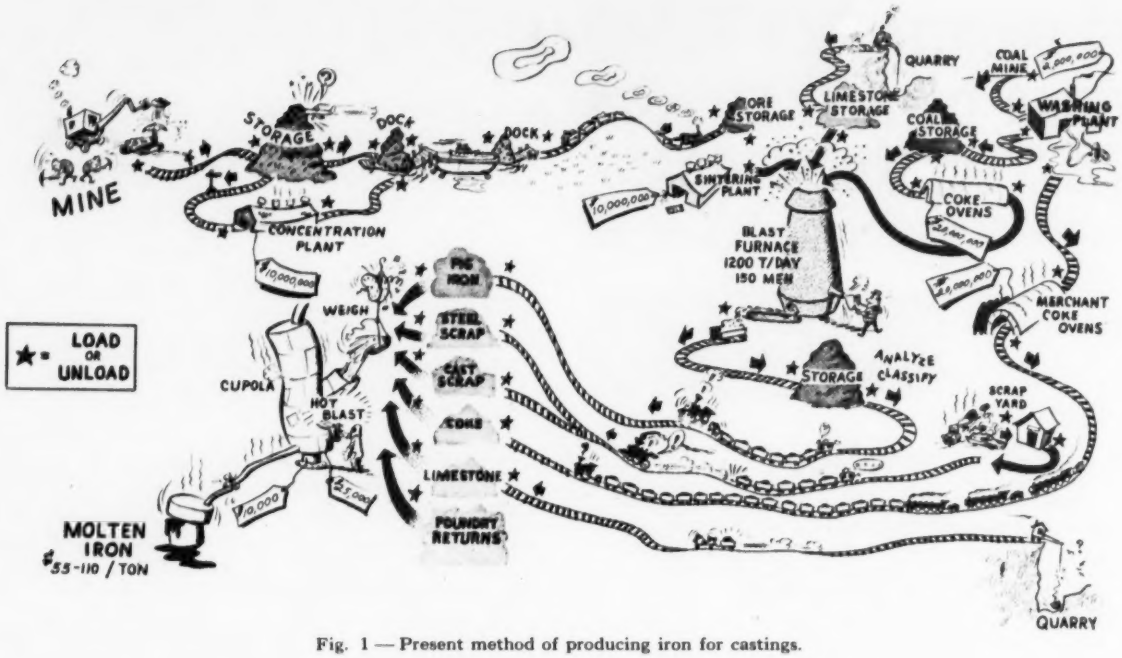

Fig. 1 — Present method of producing iron for castings.

other method so that they understand what their competitors are thinking about.

Direct-reduction processes can influence or eliminate other problems and situations which are inherent in conventional cupola melting in most foundries. Some of these are discussed below.

The prices of ferrous scrap fluctuate greatly. Although cycles appear prices are difficult to predict. Just as one example, consider what happened to the quoted price of No. 1 cupola cast iron scrap at Cleveland in 1957. It started the year at about $61 per gross ton, fell gradually to about $48 in April and May, turned up in June to reach $56 in July and August, then fell off to $38 in December. Steel scrap for cupola use varied even more. In contrast to this variable price of metallic scrap, the quoted price of iron ore remained fairly stable and consistent. Mesabi nonbessemer ore at Cleveland started 1957 at $10.85 per gross ton and finished the year at $11.45.

In the past five years (mid-1953 to mid-1958), the price of Mesabi nonbessemer iron ore has increased gradually from $9.90 to $11.45 in line with the gradual change in general economic conditions. This is an average change of about 15 per cent in 5 years, and always in the same direction in small steps. During the same period the price of cast scrap for cupolas varied over a range of almost 2 to 1, and this variation was erratic. Increased stability of the price of major raw materials for foundries would appear to be a definite advantage of direct-reduction processes.

The major sources of the ferrous metals used as raw materials by foundries fluctuate in availability in a manner which is certainly harmful to foundries. When the demand for castings is low pig iron is plentiful and ferrous scrap is abundant and cheap. When the demand for castings swings to a high level (as in time of war or threat of war) pig iron becomes hard to find in adequate amounts, sources of scrap dry up and the quality of foundry coke takes a nose dive. None of these materials, however, is needed in direct-reduction processes. The materials which are needed in the new processes remain at a more stable level of availability and cost.

Foundry coke is a problem of its own. It is expensive. Historically, quality has been variable. One of the obvious advantages of direct-reduction processes is that they require no foundry coke. Many of the processes require no coke and no coking coal.

The use of a direct-reduction process can make a foundry less dependent upon its traditional sources of melting stock. The foundry becomes more nearly an integrated producer.

Today, it appears that some new and some old processes are worthy of serious consideration of foundries. Foundrymen will ask, however, 1) can we make the kind of iron we want, and 2) how much will it cost?

In answer to the first question, virtually any useful composition of iron can be made by some direct-reduction process. Not every process will necessarily make every desired composition, but there is probably a process to make any desired type of iron. Some of the direct-reduction processes involve an electric furnace as the final stage. The proper operation of the electric furnace permits the production of irons with a wider range of compositions than is obtainable from a blast furnace or a cupola. Also, electric furnaces are noted for their ease of control as compared to a blast furnace or a cupola.

COMPARISON OF PRESENT PROCESS WITH DIRECT-REDUCTION PROCESSES

The conventional process used today for producing iron for castings is complex. It involves much han-

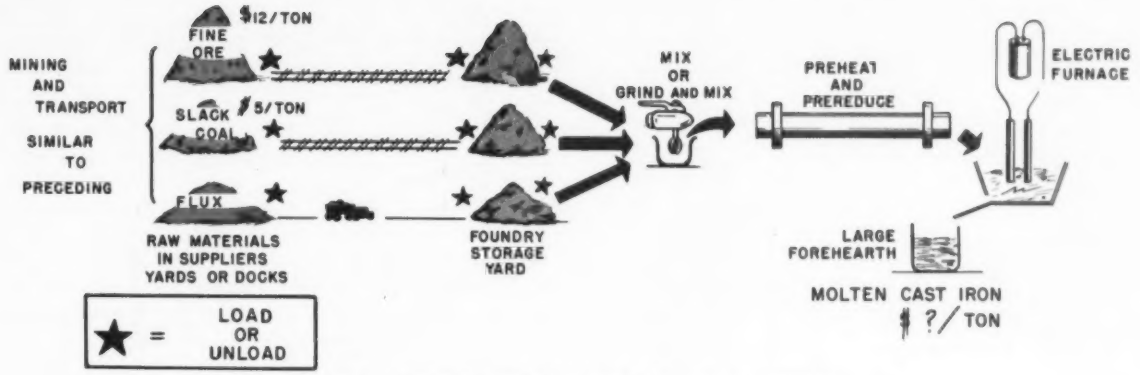

Fig. 2 — Proposed method of producing iron for castings.

dling, many people and much equipment. If one will stand back from the situation and take a look, the present situation looks something like that shown in Fig. 1.

The description of what is involved in a direct-reduction process has been deferred until later in this paper, but the elements of a typical process for use by a foundry are shown in Fig. 2. Certainly this process has some obvious advantages over the conventional method. Repeated loading and reloading of materials before they reach the foundry is minimized. Fewer agencies participate in providing raw materials, so fewer profits and markups are involved. Many miles of transportation costs are saved. Obviously, however, there are new costs incurred to offset some of these savings. The question is—how do the savings and new costs balance out against each other?

Because foundries are interested in getting molten metal, the situation on costs will be illustrated for direct-reduction processes which furnish molten metal from an electric furnace. In some types of direct-reduction processes other types of melting units might be used, but usually the electric-arc furnace has advantages which recommend it in this type of application.

To serve as a background for a discussion of costs, the general features of several types of direct-reduction processes will be described.

GENERAL DESCRIPTION OF DIRECT-REDUCTION PROCESSES

The simplest description of the direct-reduction processes of interest here is that they consist of two stages, 1) a pretreatment stage and 2) a melting stage.

Pretreatment usually involves preheating of the charge, plus complete or partial reduction of the iron oxide in the ore. Pretreatment stages usually are designed around one of the following types of equipment:

1) A rotary kiln.
2) A traveling-grate sintering machine.
3) A fluidized-bed reactor.

If reduction is completed during the pretreatment, the process is known as a "sponge-iron" process. Depending upon the quality of iron ore and reducing agent, the sponge iron may contain small or large amounts of impurities, slag and gangue. Sponge iron that is relatively low in nonmetallics may be melted much as scrap in a steelmaking furnace or as steel scrap in a cupola. Sponge iron relatively high in nonmetallics requires additional treatment to convert it to suitable melting stock.

The similarities of and differences between various processes will become clearer as five types of processes are described. These types are as follows:

1) Direct reduction in an electric furnace without thermal pretreatment of the charge.
2) Pretreatment in a rotary kiln, followed by melting (and some smelting) in an electric furnace.
3) Pretreatment on a traveling-grate sintering machine, followed by melting (and some smelting) in an electric furnace.
4) Reduction in a rotary kiln to produce some type of sponge iron which is melted in an electric furnace.
5) Reduction in a fluidized bed to produce some type of sponge iron which is melted in an electric furnace.

These types of processes will be described briefly to illustrate the variations which are possible in processing and in equipment. The intention of the descriptions is to give the foundryman a general understanding of the nature of processes of this type.

There is no intention to imply superiority of one process over another. A foundry must consider all of the processes and select the one best suited to its specific location, product and needs. This selection can require much study and analysis by people who are expert in the specific technology and economics of both the new processes and the needs of foundries.

The processes will be described on the basis of the authors' understanding of them. Some types of processes include several variations. All variations will not be discussed.

Direct Reduction in an Electric Furnace Without Thermal Pretreatment of Charge

Iron ore has been smelted in electric furnaces for many years. The most common furnace for this purpose is the Tysland-Hole furnace. About 30 Tysland-Hole furnaces are in use and about 20 more under

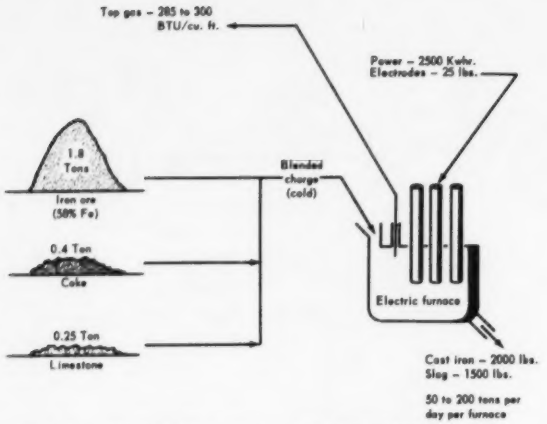

Fig. 3 — Simplified example of direct reduction in an electric furnace without thermal pretreatment of charge.

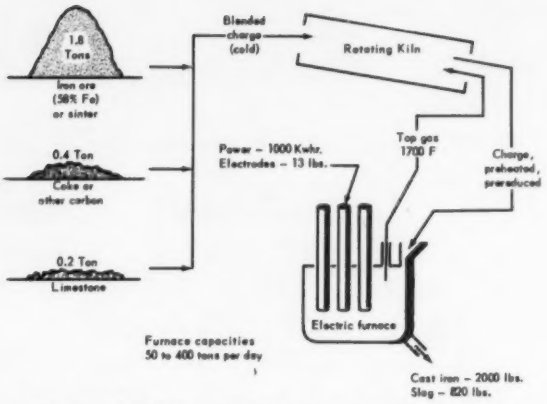

Fig. 4 — Simplified example of a process involving pretreatment in a rotary kiln followed by melting (and some smelting) in an electric furnace.

construction in Norway, Sweden, Finland, Italy, Japan, Switzerland, India, Peru, Spain, Venezuela and Yugoslavia. The largest furnaces developed so far produce about 200 tons of iron per day. These are powered by 33,000 kva of transformer capacity. The furnaces themselves are rated at 20,000 kw.

Cold ore and low-grade coke or char are charged directly into the furnace, as shown in Fig. 3. Smelting requires about 2,400-2,800 kwh per gross ton of iron. This is about 2½ times the power requirement for the newer processes which involve pretreatment of the charge. For this reason, this process is usually limited to locations where the following conditions occur simultaneously:

1) Electrical energy is cheap.
2) Metallurgical coke is relatively expensive or is not available.
3) Output is limited to a need for up to 200 or 800 tons of iron per day.

These conditions have not existed in the United States, so the process has not been used commerically here. The newer pretreatment processes have been developed to overcome some of the high cost of smelting ore directly. Because of the success of the new processes, it is unlikely that the smelting of untreated ore will receive serious attention for use in the United States. The Tysland-Hole electric furnace itself will undoubtedly be considered further because it has a long and good record of performance, but the furnace will usually be preceded by a pretreatment process in modern plants which will be considered for erection in the United States.

Cost calculations have indicated that in the United States it is probable that the cost of electric smelting of iron ore without pretreatment will be about $15 per ton of iron more than with pretreatment of the charge.

Pretreatment in a Rotary Kiln Followed by Melting (and some Smelting) in an Electric Furnace

Processes of this type are logical extensions of the simple smelting of untreated ore. Iron ore, fuel and reducing agent are fed to a rotating kiln, as shown in Fig. 4. Flux may be added with the charge to the kiln. Depending upon the method by which it is operated, the kiln can be used 1) only to preheat the charge, or 2) to preheat and partially reduce the charge. *The hot material from the kiln is discharged directly into the electric furnace* for the completion of reduction and for melting of the iron. Lime and coke or char may be added in the electric furnace. If the electric furnace is covered the rich gases resulting from reduction of the ore in the furnace are channeled back through the kiln to provide heat, and possibly some reduction.

By this type of operation, the power requirements per ton of iron in the electric furnace can be cut by 50 per cent or more. Furthermore, a particular furnace and transformer setup which will produce 200 tons of iron per day by direct treatment without preprocessing can produce 400 tons of iron per day when pretreatment of this type is added.

A distinguishing characteristic of processes of this type is the fact that the hot products from the kiln are dumped directly into the electric furnace. This saves the sensible heat in the product from the kiln. Processing between the kiln and the electric furnace is avoided.

Processes of this type are generally the most likely to fit smoothly into integration with the operations of a foundry.

The Elkem (Elektrokemisk) Process is the best known and probably the most completely developed of several processes of this type. The Stratmat Process resembles the Elkem Process.

The Orcarb Process is the same general type but makes good use of coking coal in the charge to the kiln. The coal is coked or charred in such a way that it bonds the ore and reduced iron into nodules, which are charged while hot into the electric furnace. The residual carbon in the nodules serves as the reducing agent in the electric furnace.

The rotary kiln performs two main functions in processes of this type. The kiln is used 1) to preheat the charge with relatively cheap fuel, and 2) to perform some of the reduction of the ore using heat from sources cheaper than electrical energy.

Depending upon the specific process, the degree of reduction of the iron ore which leaves the kiln can be expected to range from almost zero to about 70 per cent.

Pretreatment on a Traveling-Grate Sintering Machine Followed by Melting (and some Smelting) in an Electric Furnace

The DLM Process is the only one known to be of this type. It is quite similar in general principle to those in the preceding group. As shown in Fig. 5, the rotary kiln is replaced with a sintering machine. Fine ore and fine non-coking coal are mixed together in proportions of about 2 to 1 or 3 to 1. Flux may or may not be included in the mixture. The mixture is dampened and pelletized.

The pellets are fed to the grate of a continuous sintering machine where they are progressively 1) dried, 2) ignited and 3) carbonized. During this last step, the pellets are preheated to about 1500 F and about 60 per cent of the oxygen is removed from the ore. The hot pellets are charged directly to the electric furnace. As in the Orcarb Process, residual carbon in the pellets provides all or most of the reducing agent needed in the electric furnace.

It has been stated that the product from the electric furnace can be controlled to give a choice of 1) a pig iron containing 4 per cent of carbon, 2) a cast iron containing 2.5 to 3.8 per cent of carbon or 3) a steel containing 0.5 per cent or less of carbon. The contents of other elements such as silicon, manganese, phosphorus and sulfur can also be controlled to desired levels by 1) selection of the ore and coal, 2) control of the process and 3) operation of the electric furnace.

One feature of the DLM Process is that it requires no coke or coking coal. It can make effective use of very fine ore. Another feature is the high rate of throughput on the sintering machine. Residence time of the charge on the sintering machine is about 8 to 15 min. The processes which use a rotary kiln appear to require a residence time of about 1 to 4 hr to do the same job.

As with the processes in the previous classification, the traveling-grate process appears to be suitable for integration into a foundry operation.

The DLM Process is in the pilot-plant stage. It has not yet been used commercially, but is being considered for commercial applications.

Reduction in a Rotary Kiln to Produce Some Type of Sponge Iron Which Is Remelted in an Electric Furnace

The sponge-iron processes are characterized by the use of a processing step intermediate between the kiln and the electric furnace, as shown in Fig. 6. The Krupp-Renn Process is probably the best known of early processes. It has been used commercially in Europe, Asia and Africa.

The iron ore is reduced almost completely in the kiln. Coal, coke and/or a suitable gas is used in the kiln as 1) fuel and 2) reducing agent.

The product from the kiln is processed by mechanical, chemical or magnetic means to separate the reduced iron from gangue, ash, slag and other nonmetallics. Often this separation must be preceded by crushing and grinding to free the iron. Sometimes the separated iron is briquetted to simplify further handling and to avoid reoxidation. The final product from the extra processing step can be handled in any melting unit much as steel scrap would be handled.

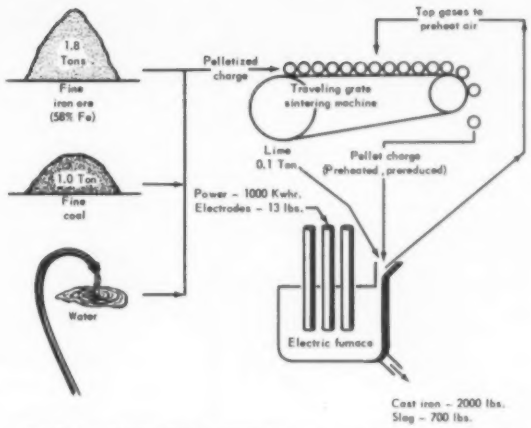

Fig. 5 — Simplified example of a process involving pretreatment on a traveling grate followed by melting (and some smelting) in an electric furnace.

When sponge iron is charged to a melting unit, the melting unit is not called upon to perform any reduction of the iron ore. (Recall that in each of the three preceding classifications, the melting unit was also called upon to perform all or part of the reduction of the ore.)

There appears to be no technical reason for promoting the integration of a sponge-iron process with an iron foundry. No sensible heat is retained from kiln to melting unit. The sponge iron can be made at a distant site and shipped to the foundry. There may be, in some situations, however, economic advantages to integration of a sponge-iron process with a foundry.

One early process of this type was developed by the U.S. Bureau of Mines. More recently, the Domnar-

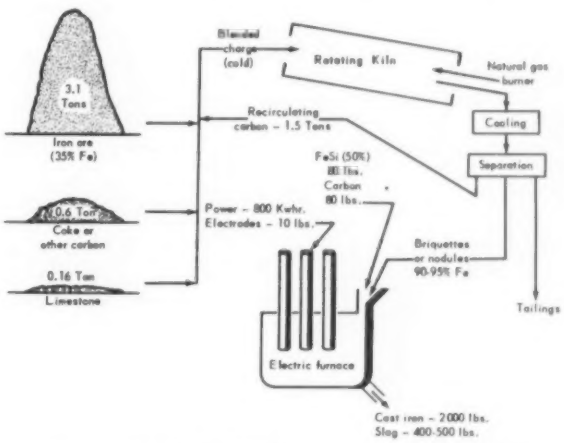

Fig. 6 — Simplified example of a process involving a rotary kiln to produce sponge iron which is melted in an electric furnace.

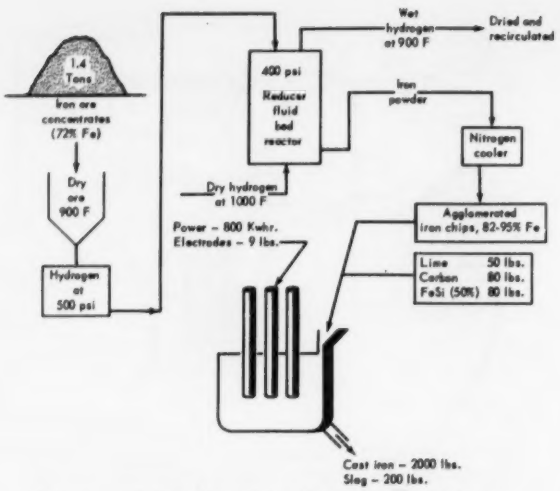

Fig. 7 — Simplified example of a process involving reduction in a fluidizer bed to produce sponge iron which is melted in an electric furnace.

fvet Process was developed in Sweden. The latest entry into the field is the R-N Process.

Reduction in a Fluidized Bed to Produce Some Type of Sponge Iron Which Is Remelted in an Electric Furnace

There are sponge-iron processes similar to those in the preceding classification, but use a modern fluidized-bed reactor instead of a rotary kiln. Whereas the rotary-kiln processes can make good use of ores of relatively low quality, generally the fluidized-bed processes require ores of very good quality.

Reduction of the ore and fluidization of the bed are accomplished by a gas (frequently hydrogen,, carbon monoxide or dissociated natural gas).

The development of processes in this classification has been hastened by steel companies which are looking for cheaper sources of low-carbon iron for use in steelmaking. This interest by steel companies is a good indication of the potential of these processes.

The H-Iron Process of this general type has been thoroughly discussed in many printed articles. One company is building a plant to produce 50 tons of iron powder per day by the H-Iron Process. This iron will not be intended for melting stock, but will be sold for premium applications.

Figure 7 illustrates the authors' idea of how such a process might be used to produce sponge iron for use in a foundry. As in the previous classification, however, there appears to be only weak technical reasons for integrating such a process with the other operations of a foundry.

Some other processes known to utilize fluid-bed reactors and gaseous reductants include the Nu-Iron (U.S. Steel), Esso-Little, Stelling and Madaras Processes.

The Nu-Iron and Esso-Little Processes are believed to be in pilot-plant operation. The Madaras Process based on cracked natural gas has been (or is being) used to produce metal for a small Mexican steel company.

The situation on the cost of producing molten cast iron by direct reduction will be described on the basis of a process involving two integrated stages: 1) continuous preheating and some reduction in one piece of equipment, followed by 2) continuous smelting of the hot, partially reduced charge in an electric furnace to produce a common composition of gray iron.

COSTS

The costs which will be given are based on calculations made for several different processes of this general type. The costs purposely are presented in such a form as to avoid identification with any specific process. The specific processes differ technically in numerous ways, but differences between the processes in one application can be less than differences between the same process in various situations. There is an excellent chance that the actual cost of production of molten iron in a specific foundry may be materially less than the costs which are given here.

The cost estimates given here apply to plants and processes of a type and size suitable for integration with an iron foundry. If similar processes are used on a larger scale to produce pig iron for sale, the estimated costs will generally be somewhat lower.

The capacity of the smelting plant has a large influence on its capital cost and cost of production. Table 1 shows that a prereduction and smelting plant for 100 tons of iron per day can be expected to cost about $2,500,000, and a plant for 400 tons per day can be expected to cost about $6,000,000. The smaller plant will produce molten iron for about $61 per net ton. The larger plant will produce for about $47 per net ton.

Details of the cost estimates for the 400-ton plant are given in Table 2. These same bases were used to calculate the costs for other processes mentioned here.

How do these costs compare with the cost of melting in a cupola? That depends on how much iron you want and on how much you are now paying to melt in a cupola.

Before you make a comparison, be sure you know your present cost of melting and have included all

TABLE 1 – ESTIMATED CAPITAL INVESTMENT AND NET COST OF PRODUCTION OF MOLTEN IRON FOR A PREREDUCTION AND SMELTING PROCESS INTEGRATED WITH AN IRON FOUNDRY

Cost	100 Net Tons of Cast Iron Per Day	400 Net Tons of Cast Iron Per Day
	Total Dollars for Plant	
Capital Investment	2,500,000	6,000,000
	Dollars Per Net Ton of Molten Iron	
Raw Materials	30.90	30.90
Electrical Energy	7.50	7.00
Wages and Salaries	16.00	4.20
Insurance, Local Taxes, Repairs, Incidentals ...	3.50	2.60
Amortization on Investment	3.60	2.10
Net Cost of Production..	61.50	46.80

the items listed in Table 2. If your direct-labor rate is more or less than $2.50 per man-hour, correct Table 2 for this and other differences. Make sure that costs for amortization and taxes on your entire melting system (including building and storage yard) are included in your metal costs. Include power costs for blowers and charging equipment. Include at least part of the cost of your chemical laboratory.

Use delivered costs of raw materials, and include additions of silicon or manganese to the charge. Allow for melting losses. Figure the cost of your returns as equal to the costs of purchased No. 1 cupola cast scrap. If you have a water-cooled cupola, what does the water and pumping cost? If you have a hot-blast cupola, what does the fuel cost? Do not overlook the original and maintenance costs on instruments. Figure coke on overall consumption, not on your coke ratio per charge.

After you calculate your cost of producing a ton of iron ready to pour, your analysis might shape up something like one of those given in Table 3.

If the total cost of a net ton of molten iron from your cupola is calculated on the foregoing basis to be less than about $55, either 1) you are doing an unusually effective job of efficient and economical purchasing and melting or 2) you have overlooked some of the costs.

After your cost of melting in a cupola has been established, and Table 2 has been adjusted to your particular situation, you are then ready to use Table 4 (or some modification of it) to estimate whether you should give further consideration to one of the new processes.

If your analysis makes the new processes come even close to your present cost of melting in a cupola, the new processes deserve your further study. The costs given for the new processes are by no means the lowest which can be obtained under favorable conditions.

TABLE 2 – ESTIMATED CAPITAL INVESTMENT AND NET COST OF PRODUCTION OF MOLTEN IRON FOR A PREREDUCTION AND SMELTING PROCESS INTEGRATED WITH AN IRON FOUNDRY AND PRODUCING 400 NET TONS OF MOLTEN IRON PER DAY

Item	Basis	Cost	Subtotal or Total
Capacity	400 net tons of molten iron per day, 350 days/year, 24 hr/day, 140,000 net tons per year		
			Total Dollars for Plant
Capital Investment	Facilities for receiving, storage, grinding, mixing, preheating, and prereduction. One electric furnace at 33,000 kva. Pig machine, buildings, utilities, mixing ladles, cranes, laboratory. Construction, installation, and engineering. Trackage. Electrical substation.		6,000,000
			Dollars Per Net Ton of Product
Raw Materials			
Iron ore	$12 per GT delivered	20.20	
Coal	$ 6 per NT delivered	6.30	
Limestone	$ 3 per NT delivered	1.20	
FeMn	$245 per NT	0.90	
Electrodes	Prebaked carbon at $0.14 delivered	1.70	
Cooling water		0.40	
Refractories		0.20	
			30.90
Electrical Energy	Includes motors, smelting, and incidental. 7 mils per kwh		7.00
Wages and Salaries	Direct labor – 54 men at $2.50/hr	2.70	
	Supervision – 10% of direct labor	0.30	
	Laboratory	0.10	
	Indirect labor, payroll expenses, and overhead (40% of direct labor)	1.10	
			4.20
Insurance, Local Taxes	Insurance and taxes (2½% of capital)	1.10	
Repair, Incidentals	Miscellaneous	1.50	
			2.60
Amortization	20-year basis		2.10
Gas Credit	None taken. Potential credit of $1.15 per net ton		0.00
Total Cost of Production			46.80

SOME PROBLEMS INVOLVED IN DIRECT REDUCTION

The integration of a direct-reduction process with a foundry operation will not be without its problems. Each foundry must decide whether the potential advantages outweigh the problems.

The foundry will require a supply of iron ore of suitable quality and characteristics. Suitable arrangements and contracts will have to be made, but the supply of iron ore will be only a normal purchasing and scheduling problem. The foundry may find it advisable, however, to stock a reserve of iron ore in its own yard. The plant and labor force on which Table 2 is based includes facilities for grinding and screening ore and coal, if this is necessary. Facilities also include storage and handling of ore and coal.

The major problem which a foundry will face in integration is probably that of handling and scheduling molten metal. The electric smelting furnace should run continuously, certainly for 5 days a week, preferably 7 days a week and around the clock. Shut-

TABLE 3 – COST ANALYSIS

	Dollars Per Net Ton of Unalloyed Iron Melted in a Cupola and Ready to Pour		
	Small Foundry With Relatively High Costs	Large Foundry With Relatively Low Costs	Possible Average Foundry
Metal for cupola	61.00	37.00	40.00
Direct labor & Direct supervision	9.40	3.70	5.00
Coke	20.00	5.00	6.40
Supplies, repairs, misc. materials	7.60	1.60	3.10
Prorated share of general foundry overhead, including amortization of equipment	12.00	2.90	3.90
Conversion cost	49.00	13.20	18.40
Total Cost	110.00	50.20	58.40

TABLE 4 – ESTIMATED POTENTIAL SAVINGS AND RETURNS ON INVESTMENT FOR PREREDUCTION AND SMELTING PROCESSES INTEGATED WITH AN IRON FOUNDRY

100 Net Tons of Iron Per Day				
Cost of Iron Melted in a Cupola, dollars/net ton..	60	70	80	90
Cost of Iron Produced by New Process, dollars/net ton	62	62	62	62
Saving, dollars per net ton	none	8	18	28
Saving, dollars per year....	none	280,000	630,000	980,000
Annual Return on Investment (before Federal taxes), per cent of capital investment	none	11	25	39
400 Net Tons of Iron Per Day				
Cost of Iron Melted in a Cupola, dollars/net ton..	50	60	70	80
Cost of Iron Produced by New Process, dollars/net ton	47	47	47	47
Saving, dollars per net ton	3	13	23	33
Saving, dollars per year....	420,000	1,820,000	3,220,000	4,620,000
Annual Return on Investment (before Federal taxes), per cent of capital investment	7	30	53	77

downs over a week end may be feasible, shutdowns overnight probably will not be. In continuous operation, the furnace should require shutdowns for relining only once every year or two.

If the foundry operates on only one or two shifts, sufficient mixer (forehearth) capacity can be provided to store molten iron until the next shift starts. The equipment and labor in Table 2 are calculated for a plant in which the electric furnace operates 24 hr per day and the foundry pours metal 12 hr a day. With experience, a foundry might learn to vary the rate of output of the electric furnace to approach the foundry's demand for metal. It will almost certainly be necessary, however, for the process to include a forehearth to store metal to take care of a fluctuating demand by the foundry.

The plant should also be provided with a pigging machine to dispose of excess metal. Such equipment was included in the plant in Table 2. The disposition of this pigged metal will present about the same problem as the disposition of the foundry's return scrap.

The use of a process based on iron ore as a raw material can raise a question about what a foundry will do with its returns. Today, a foundry using the conventional cupola process will remelt its returns simply because this is the cheapest thing to do. With an electric furnace spewing out relatively cheap hot metal, the foundry will find that it has several outlets for returns. They can be melted in the electric furnace along with the ore charge, they can be sold, or part can be melted and part can be sold. Electric power for melting cast iron will probably cost about $4 per ton. With the ability to consume or market its returns as it sees fit, the foundry can turn periods of high scrap prices into another source of income.

As another alternative, the foundry might provide a second and smaller electric furnace for melting only. This furnace could be used for melting pigged metal or returns (both of which would be about the same composition), for superheating some molten metal, or for producing irons of special compositions.

CONCLUSION

These processes are available for foundries to produce their own iron directly from ore. Foundrymen owe thanks to many investigators who have, over a period of a century, developed the processes and put them into pilot plants (and, in a few cases, into commercial operation). The investigators were laying groundwork for an industrial change in the future. So far as some foundries are concerned, the future may be here today.

SOME FOUNDRY PROBLEMS IN THE DEVELOPMENT OF A NEW MARINE PROPELLER ALLOY

By A. J. Smith

ABSTRACT

The development of a casting practice for a new alloy is sometimes difficult because of the peculiar characteristics of the new material. This is especially true when the castings are large in size and weight such as large ship propellers. Experimental work must necessarily progress slowly. Some of the problems encountered by the foundry and their eventual solution are described. Material, melting, molding, refractories, fluxes, gas and feeding, are discussed as applied to nickel aluminum bronze. A comparison of engineering properties and service performances of the standard manganese bronze propeller alloy and the new superior nickel aluminum bronze is outlined.

INTRODUCTION

Shortly after World War II, the oil transportation industry began a program of building supertankers to replace the outmoded ships of the pre-war and war years. Shipyards throughout the United States were given the boost needed to revive an industry suffering from post-war palsy. These new high-powered ships were equipped with manganese bronze propellers which had long been recognized as the standard alloy for such marine applications.

After the ships had been in service for a few years the propellers exhibited more than the usual amount of wear. This condition was not entirely unexpected, and can readily be appreciated when a comparison of the requirements for the pre-war and post-war propellers is made. For example, a relatively high-powered, high-speed, pre-war tanker was equipped with a 6,000 hp turbo-electric engine driving its 19 ft 6 in. diameter propeller at a speed of 90 rpm. The post-war 28,000 ton tanker was equipped with a 15,000 hp turbine engine driving its 22 ft diameter propeller at a speed of 112 rpm.

Differences greater than these can also be demonstrated when comparisons are made between the pre-war reciprocating engine-driven vessels with propeller speeds of 65-80 rpm, and some of the modern passenger liners having propeller speeds as high as 155 rpm. The amount of water pushed by a propeller is directly proportional to the horsepower, which in turn is proportional to the amount of scrubbing action on the propeller surface.

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A program was initiated by the Central Technical Department of the author's company[1] to follow the wear characteristics of a large number of modern tanker propellers with varying lengths of service and under many conditions of operation. The results of this study (Fig. 1) establish the wear characteristics which could be expected from manganese bronze for such service.

As the propeller is an extremely costly item, and vital to the operation of the ship, it was obvious that a material with better wear characteristics was needed. The efficient operation of a ship means a minimum of tie-up time, and even a few unscheduled days in drydock can spell the difference between profit and loss for the operator.

A relatively small number of ships were driven by propellers made of other alloys such as aluminum bronze and stainless steel. For harbor craft, cast iron or steel was used, but they were for the most part unsatisfactory for large ocean-going vessels.

The development of a new propeller alloy pre-

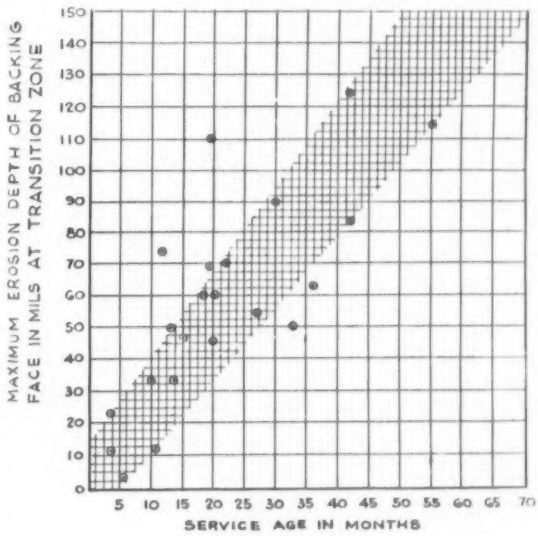


Fig. 1 — Corrosion vs. time plot of manganese bronze propellers on large single-screw vessels. Each point represents one vessel. Note that most of the values fall within the comparatively narrow shaded band.

sents a major problem to the foundry. Castings of this size and cost (the author's company's foundry produces propeller castings ranging from 6,000-120,000 lb rough weight) preclude any hasty manufacturing plans. The vital part which the propeller plays in the performance and safety of a ship would prevent both manufacturer and ship owner from jumping to a premature selection of an untried material. Earlier efforts had been made to confine the manganese bronze chemistry to a more limited range, and to make slight modifications in the composition. Modifications such as additions of nickel or tin to improve wear resistance and mechanical properties were made. Although some minor improvements in tensile properties and wear resistance were developed, it was felt that more definite improvements could be made with a new alloy.

It is the intent of this paper to present a general review of some of the more pertinent foundry problems encountered in developing a new propeller alloy designed to meet the requirements of the manufacturer, user and the various marine classification societies throughout the world.

EARLY INVESTIGATIONS

Prior to any metallurgical or foundry development work a cooperative research program was established between Bethlehem Steel Co., Shipbuilding Div. and the International Nickel Co.[2] to select a group of reputable alloys, and a method of comparing their wear resistance under laboratory conditions simulating propeller service. Because of the extensive and complex nature of this program, time and space will allow only a brief description of some of the general findings.

Several alloys chosen for preliminary comparative tests were selected on the basis of prior research, experience and a survey of the available literature.

The method for evaluating the wear characteristics was to spin flat cast, machined blocks in sea water at a nominal tip velocity of 27 ft per sec for 60 days. Although test specimen size, spin time and spin equipment have undergone some modification since these early runs, later results have been in substantial agreement.

The final choice of alloy was made after casting several 200-300 lb crucible furnace heats to determine handling qualities of the various materials under consideration. It was found that nickel aluminum bronze had the best combination of wear resistance, mechanical properties and foundry handling characteristics, although this latter consideration was far more difficult than for the standard manganese bronze alloy.

The chemical composition, mechanical properties and preliminary spin test results of nickel aluminum and manganese bronze are shown in Table 1.

Working with a new and unfamiliar alloy, the foundry was confronted with several problems which had to be solved at least in part before any production castings could be made. Such general subjects as raw material specifications, metallurgical control, melting, molding materials, risering and refractories were given primary consideration.

Production propeller heats are run in large oil-fired reverberatory melting furnaces having a combined capacity of 130,000 lb. However, it was felt that small oil-fired crucible furnaces would enable the author's company to develop the answers to some of the problems. No difficulty was experienced in melting in this latter type furnace, and progress was made in developing the properties of test specimens, influence of pouring temperature upon mechanical properties, use of fluxes, castability, etc.

It was found that reproducible mechanical properties could be obtained from test coupons made to A.S.T.M. B208-54 (Fig. 1 (a)*) the double keel block (Fig. 3*) and the double horizontal full-web type coupon.[3] Slightly better properties were obtained with the latter bar. Smaller gates than those used for manganese bronze were necessary to obtain maximum properties.

The influence of pouring temperature upon mechanical properties was found to be insignificant, as for manganese bronze. The results of a typical set of test data, which has since been reproduced several times, are shown in Table 2. It must be appreciated, however, that gas solubility increases with an increase of temperature and, in that respect temperature may influence the mechanical properties.

*Figures referred to are A.S.T.M. figures.

TABLE 1 — TEST RESULTS OF NICKEL ALUMINUM AND MANGANESE BRONZE

Item	Nickel Aluminum Bronze	Manganese Bronze
Chemical Composition, %		
Copper	78 — 81	55 — 60
Zinc	In "all others"	Remainder
Nickel	4.5 — 5.5	—
Iron	3.5 — 5.5	0.9 — 2.0
Manganese	0.5 — 1.0	0.3 — 0.9
Aluminum	9.0 — 10.3	0.7 — 1.0
Lead	0.01 max.	0.4 max.
Tin	In "all others"	1.5 max.
All Others	0.5 max.	—
Mechanical Properties (Normal Range)		
Yield	35-43,000 psi	27-33,000 psi
Tensile	80-95,000 psi	60-72,000 psi
% Elong. in 2 in.	15-30	20-35
Proof stress	28,000 psi	14-16,000 psi
Brinell hardness no.	152 — 190	112 — 130
Fatigue — air	21-25,000 psi	9-14,000 psi
Fatigue — salt water	18-22,000 psi	9-12,500 psi
Density — lb/cu in.	0.273	0.297
Spin Test		
Weight loss — grams	2.48	9.21
Loss — Mg/in.^{2}/day	6.5	24.0
Mg/dm^2/day	99.0	376.0
In. pentration/yr.	0.019	0.063
At tip — in.	0.005	0.012

Spin Test Data:
Nominal tip velocity — 27 ft/sec.
Exposed area — 6.5 sq in.
Average sea water temp.:
First 18 days — 14.7 C (58.5 F) Range: 9.0-19.5 C (50-66 F)
Last 42 days — 27.5 C (81.5 F) Range: 18.0-31.5 C (64-88 F)

NOTE: Yield measured by 0.5% offset method.

In general, the metal did not handle as easily as manganese bronze. There appeared to be less fluidity and a greater tendency toward dross (aluminum oxide) entrapment in the castings.

Shrinkage was somewhat greater than for manganese bronze, and it was apparent from the work done on the small castings that risering would require considerable care if sound castings were to be made. Insulating and exothermic materials used for riser sleeves and padding worked satisfactorily as for manganese bronze, and no difficulty was anticipated with these materials. Later, however, experience on production size castings discounted the results of this early experimental work.

Certain proprietary fluxes were found beneficial in reducing melting loss and in producing cleaner castings. Here, however, this experimental work did not aid in developing production practices, as fluxing in the reverberatory furnace proved to be an entirely different matter.

EXPERIMENTAL FURNACE WORK AS APPLIED TO PRODUCTION MELTING

The first production heats indicated that considerably more experimental work was in order before satisfactory castings could be made. It was evident that melting nickel aluminum bronze in crucible-type furnaces was not indicative of the results that could be obtained in the larger reverberatory furnaces, and that many operational problems remained to be solved. This fact led to a short but concentrated experimental and development program on melting in a scale model reverberatory furnace whose interior dimensions were reduced 6 to 1 from the average interior dimensions of the largest production furnace. An adjustable tilting oil burner was fitted to the firing end.

For the most part these developments on melting in the small furnace were applicable to production furnace operation and resulted in a comparatively inexpensive and rapid solution to many problems, some of which are discussed briefly below.

Burner Position. It was found that nickel aluminum bronze could be melted more rapidly when the burner flame impinged on the metal. The production furnaces were designed so that the burner flame would be quite far removed from the metal to prevent excessive zinc losses in manganese bronze. A new adjustable tilting burner was added to these furnaces to allow flexible operation of melting both alloys without further modifications. It is appreciated here that there exists a variety of burner locations for reverberatory furnaces from one foundry to another, and that such modifications are not necessary in all foundries. It can be generally stated, however, that furnaces equipped with burners close to the metal line will melt nickel aluminum bronze more efficiently than burners remote from this area. This is not as obvious as it might appear to be as, theoretically, melting in a reverberatory furnace is accomplished by direct contact with the gas and heat radiated from the refractory.

Combustion. Most of the results of the pilot-plant furnace study were not applicable to production heats. Although it was well appreciated that a neutral furnace atmosphere was most desirable for efficient melting, such a condition was almost impossible to maintain. Theoretically, a neutral or oxidizing atmosphere would prevent hydrogen absorption by the metal. Likewise, a reducing atmosphere would prevent oxidation of the aluminum resulting in the formation of dross.

However, it was found that combustion conditions were constantly changing during the melting period because of natural air leaks in the furnace. These fluctuations could be prevented only by extreme oxidizing or reducing atmospheres both of which were most undesirable. Good furnace practice required a careful check and manipulation of the burners to prevent excessive gas absorption or oxide formation. By such operation, which can be considered somewhat of an art, rapid meltdown and elimination of many combustion problems can be accomplished.

Fluxes. The primary functions of a flux are, 1) to react with the oxides present on the metal bath, 2) to prevent the formation of additional oxides and 3) to form a fluid slag to prevent gas absorption by the metal.

Slag covers are intended to perform the third function and in addition, for high zinc alloys, to prevent the volitilization of the zinc.

In discussing the subject of fluxes with people actively engaged in smelting and refining, a wide divergence of opinion on the use of flux at all or in the type of flux to use was found. None had

TABLE 2 – THE INFLUENCE OF POURING TEMPERATURES UPON THE MECHANICAL PROPERTIES OF NICKEL ALUMINUM BRONZE

Temp. F and (C)	Yield Strength psi	Tensile Strength psi	% Elon. in 2 in.
2260	36,200	91,550	27.0
(1238)	37,150	91,000	27.0
2200	38,150	91,300	26.5
(1204)	36,500	90,800	27.0
2150	38,800	90,950	23.5
(1177)	42,100	92,050	28.0
2100	39,750	91,950	26.5
(1149)	41,700	92,550	27.0
2050	36,950	93,350	28.0
(1121)	41,050	92,950	26.5
2000	36,550	92,850	26.5
(1093)	37,750	92,500	26.0
1950	39,200	89,500	19.5
(1066)	37,350	84,800	16.5
1940	Froze in Ladle		
(1060)			

NOTE: Temperatures were taken at the mold and represent the metal temperature at the time it entered the test bar cavity. In pouring a propeller with test bars attached, the metal may be quite cold when it reaches the test bar cavity. Therefore, allowances must be made for this. Test coupons were of the A.S.T.M. 208-54 (Fig. 1a) double keel block test bar.

any experience in fluxing aluminum bronze in reverberatory furnaces as such. Ingot is always made in rotary-type or low-frequency induction furnaces. All agreed, however, that fluxes were essential when melting charges of dirty scrap.

The most effective fluxes for rotary furnace treatment of aluminum bronzes appear to be the fluorides (potassium titanium fluoride or anhydrous potassium fluoride) used singly or mixed. Sodium chloride and potassium chloride, borax salt mixes, sal-ammoniac and manganese sulfate are also used. Such compounds are generally the basis for some proprietary fluxes which had been used with marked success in the crucible furnaces, but with an equal lack of success in the reverberatory furnace.

Broken bottle glass has no actual fluxing action and is intended only as a protective cover. It is commonly used in foundries in this country and abroad to minimize loss of volatile elements, to reduce oxidation and to minimize gas absorption.

Charcoal is another material commonly used as a cover for aluminum bronze. It has the advantage of being a good deoxidizer for copper. Its chief disadvantages are in its faculty for introducing moisture into the metal if added to the molten charge, and in its ability to combine with the iron in the material if left in contact with the molten metal for any extended time.[4]

Perhaps one of the most objectionable characteristics of fluxes and covers is their ability to attack the furnace linings forming additional and difficult to control refractory slags. From the standpoint of the author's company no greater hindrance could be introduced into the reverberatory furnace melting practice.

Table 3 summarizes some of the pertinent properties of available fluxes. It will be noted from the table that fluorspar has a high melting point of 2480 F (1360 C). Since one of the reasons for a flux is to get an early liquid slag, it is evident that something else is required.

TABLE 3 – FLUX PROPERTIES

Material	Melt Point, F and (C)	Al_2O_3 "Solvent"	Erode Refractory	Silica "Solvent"
Fluorspar	2480 (1360)	Yes	Yes	Yes
Glass	1500 (816)	No	Some	Yes
Borax	1366 (741)	No	Yes	Yes
50% Borax, 50% Caustic Soda	Low	No	Yes	Yes
Caustic Soda	640 (338)	No	Yes	Yes
Potassium Fluoride	1616 (880)	Yes	Yes	Yes
Sodium Fluoride	1827 (997)	Yes	Yes	Yes
Cryolite	1832 (1000)	Yes	Yes	Yes

While the melting point of glass is about 1500 F (816 C) this is really a softening point, and it is felt that the glass would make a quite viscous slag until heated to well over this temperature.

Borax has a relatively low melting point of 1366 F (741 C), but does not have an active affinity for aluminum oxide. The same is true of caustic soda or 50 per cent borax – 50 per cent caustic soda.

It was felt that a flux composed of a borax base, with some quantity of potassium fluoride or sodium fluoride and cryolite, might be successful because the borax would furnish the low temperature fluidity for earlier cover while the fluorides would furnish the "solvent" action for aluminum oxide removal.

The conclusions, based upon experience in both the experimental and production furnaces, indicated that any and all types of fluxes tried to date were unsatisfactory. In general, fluxes appeared to perform in a satisfactory manner during the initial stages of melting, but then appeared to "dry out" and contribute to the general drossing condition in the furnace. This materially increased the meltdown time (by insulating the metal), decreased the yield and attacked the furnace walls.

The use of fluoride-type fluxes was found somewhat beneficial when added to the ladle during tap out. However, the benefits were counteracted by the time required to remove the fluid slag, the resultant loss in temperature and the annoyance and health hazard of pungent fumes from the fluorides.

GAS ABSORPTION

Nickel aluminum bronze, unlike manganese bronze, is susceptible to gas absorption during melting. Theoretically, this should only be true when the melting atmosphere is on the reducing side. As stated before, however, large furnace atmospheres are extremely difficult to control as combustion conditions are under constant fluctuation. In actual practice gas is picked up by the metal during a reducing period or from contaminants on the metal charge. It is widely accepted that the subject gas is hydrogen and, therefore, no attempt will be made in this discussion to develop the theory of gas absorption which is adequately covered by many texts.[5]

The average foundryman or metallurgist is usually not aware of the presence of gas in molten metal unless the metal spews or puffs in the riser during solidification. It is most common, however, to gas during melting and, depending upon the amount of gas and the size of the casting which in turn governs the rate of solidification, the gas may or may not be detrimental to the casting.

The question of how or why it is known that a heat of metal has been gassed is obviously in order. The laboratory has tested a large number of heats (over 150) melted in crucibles, experimental reverberatory, three production reverberatories, a rotary and a line frequency electric furnace and, without exception, all heats were gassed to some extent. It is true that the best furnace practices can minimize this condition, but in the author's experience it

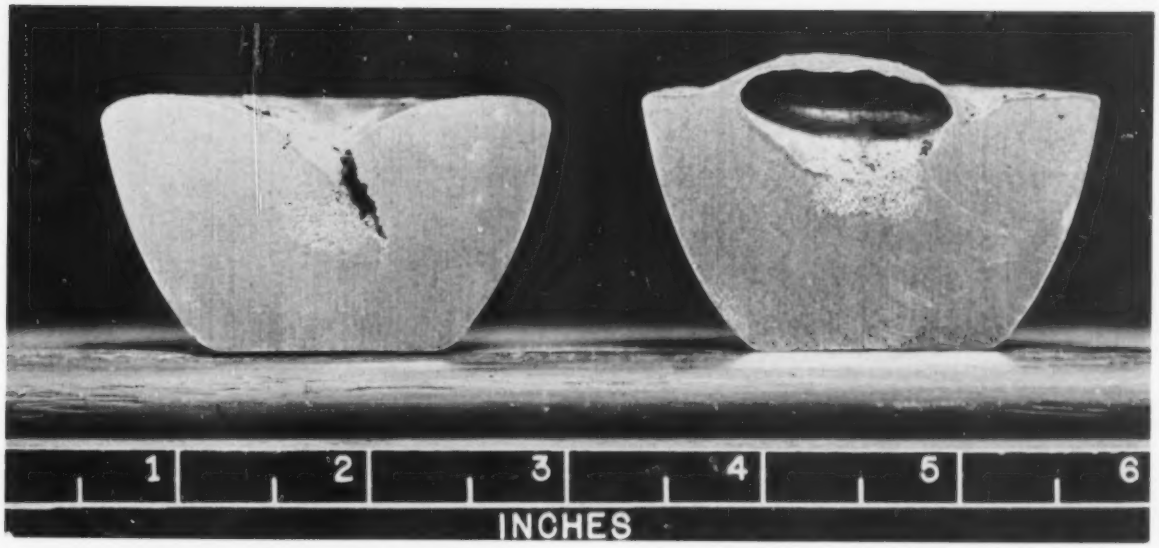


Fig. 2 — Two specimens from the same reverberatory furnace heat of nickel aluminum bronze. The specimen on the left was allowed to solidify under atmospheric pressure, while the specimen on the right solidified under vacuum.

cannot be completely eliminated unless melting is done under a vacuum. At the present time, it is economically infeasible to build vacuum melting equipment to melt large nickel aluminum bronze propeller heats.

The presence of gas in metal can be determined by a piece of equipment known as a vacuum tester, which has been described in detail by Walther, Adams and Taylor.[6] Although not commonly employed in brass and bronze foundries, it is becoming widely used in the aluminum casting field. It consists mainly of a vacuum pump and accessible vacuum chamber. The procedure for testing metal is to pour a sample either from the furnace or ladle into a dried and coated crucible, place it in the transparent vacuum chamber (usually a sealed bell jar), start the vacuum and observe the behavior of the specimen during solidification.

If gas is present the removal of atmospheric pressure down to 25-30 in. of mercury will allow the gas to come out of solution. The more gas present, the more violent the reaction, and the smaller the amount of vacuum required to effect the reaction. A control specimen from the same sample of molten metal handled in an identical manner, and allowed to solidify under atmospheric pressure unless heavily gassed, will generally show normal shrinkage. This is shown by Fig. 2.

The next question arises as to the influence of gas upon mechanical properties and casting quality. To answer this question a method had to be developed to degas the metal. It is known from experience that some castings have been poured from gassed metal wherein the gas had no noticeable influence upon casting quality or mechanical properties. It is assumed in this case that the gas was not present in sufficient quantity to visibly harm the casting. There are other cases, however, where the casting poured from gassed metal spewed out of the riser. The resultant casting contained large numbers of holes and mechanical properties were inferior to anticipated values. The problem was then to determine when a melt required degassing and how to remove the gas if removal were required.

To date no quantitative test for gas has been developed. If such a test should be developed later it will then be necessary to determine the tolerable gas content where a degassing procedure will not be necessary.

A common method of degassing adopted by the foundry involves the use of an inert gas to flush the dissolved gas by mechanical agitation.[7] The effectiveness of this treatment is shown by Fig. 3. This photograph shows two double horizontal full web-type test bars which have been split through the center. The specimen to the left represents metal from a ladle after tap. During solidification and as shrinkage occurred, the dissolved gas was present in such a large quantity that it resulted in spewing through the riser. The specimen to the right represents the same metal after the degassing treatment. Although gas was still present as evidenced by the vacuum test, it was reduced to a concentration low enough to remain in solution in this size casting. Mechanical properties of both specimens (Table 4) indicate the influence of gas upon this factor. The results of this test have been substantiated several times.

It must be appreciated that the larger the section size of the casting, the greater the influence of hydrogen. For example, a small casting may solidify

TABLE 4 – MECHANICAL PROPERTIES OF WEB-TYPE TEST BARS

Specimen	Yield Strength	Tensile Strength	% Elong. in 2 in.
A	46,180	86,550	12.5%
A_1	47,300	88,200	12.5%
B	47,550	97,000	25.0%
B_1	46,300	95,900	23.5%

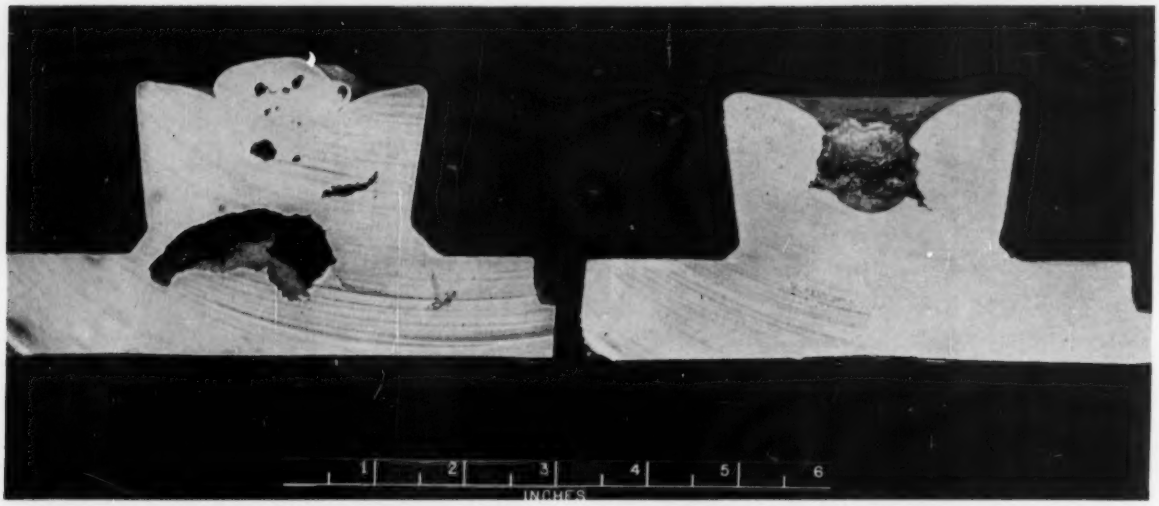


Fig. 3 — Cross-sections of nickel aluminum bronze full web-type test bars. Both specimens were from the ladle after tap-off and solidified under atmospheric pressure. The specimen on the left is from before degassing treatment, and the one on the right from after degassing treatment.

so rapidly that a given percentage of gas is retained in solution without obvious harmful effects upon the casting. As the section size of the casting increases with the resultant increase in solidification time, the intensity of the problem increases. This has been demonstrated as follows:—

a) From the same ladle of untreated gassed metal (as indicated by the vacuum tester), a small cup specimen (1 lb) and the comparatively larger web-type test coupon is poured (18 lb). In the case of the cup specimen normal shrinkage occurs, while in the case of the test coupon, sufficient gas is rejected during solidification to build up pressure under the shrinking riser causing the riser metal to spew out over the top. Figure 4 is a photographic demonstration of this principle.

b) The above experiment is carried one step further, but this time with metal that has been given a degassing treatment. The cup specimen and the test coupon both shrink normally under atmospheric pressure. The gas is not sufficiently high this time to concentrate in any large volume in the test coupon. However, the next casting poured from this same metal is a propeller casting, let us say, in the neighborhood of 10,000 lb. When the mold is filled with metal, solidification begins at the mold surface and develops most rapidly in the thinner sections. As solidification progresses, the gas is rejected in larger volume and tries to escape through the liquid metal.

If the time from the liquid to solid state is appreciable, the riser metal and the heavy hub section

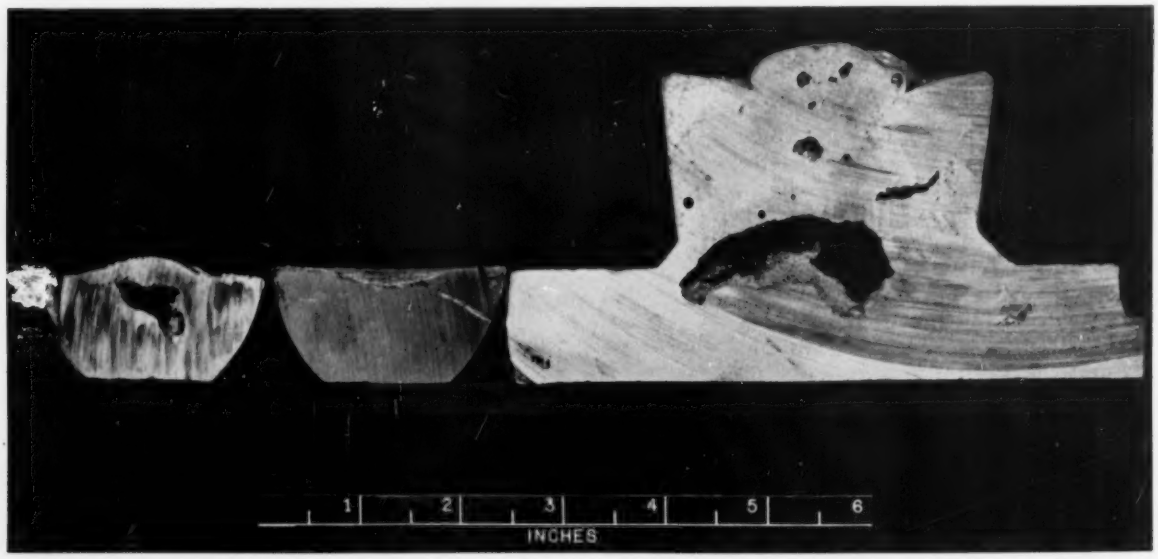


Fig. 4 — Three specimens from the same reverberatory furnace heat of nickel aluminum bronze. The specimen on the left was solidified under vacuum and shows a gassed metal condition. The center specimen was solidified under atmospheric pressure and the gas remained in solution. The right specimen was solidified under atmospheric pressure and the gas came out of solution.

become colder and less fluid and lack the ability to allow the gas to escape and the riser to perform its function. The result is that the gas is entrapped in the casting. The broken up areas of concentrated gas which are entrapped as the metal solidifies, result in many holes which are eventually diagnosed as shrinkage cavities. Actually, of course, the gas has prevented feeding which results in shrinkage defects.

Melting nickel aluminum bronze cannot be accomplished without some degree of gas absorption. However, with carefully controlled rapid melting, the use of hot dry ladles and an effective method of degassing, it is possible to deliver to the mold a metal containing a tolerable gas content.

MOLDING MATERIALS

There appears to be a wide variation in the type of molding materials used by propeller foundries throughout the world. For many years, the author's company's foundry has used a natural bond baked gravel sand for propeller molds. During the nickel aluminum bronze casting development period, experiments were made to determine the possible benefits of casting in a cement bonded sand which had been given wide publicity in the foundry industry.[8] Cement bonded sands were compared to the standard gravel sand.

It was concluded that the disadvantages of the cement sand outweighed its advantages for use in the shops and under the conditions of operation.

Advantages of the cement process were found to be as follows:

1) Molds are air dried and require no costly drying equipment.
2) No highly skilled personnel are required for molding.
3) Molding material has greater strength than sand and thereby the casting is less subject to distortion.

Claimed advantages which we were not able to substantiate were:

1) Propellers can be cast closer to size with concomittent savings in machining costs.
2) Better quality casting can be made in cement.
3) Foundry labor costs can be reduced.

Disadvantages of the cement sand process from the author's company's standpoint were found to be:

1) A well heated shop is required to prevent freezing of molds in winter.
2) Molding materials are more costly.
3) The molding material must be used within a few hours after mixing.
4) Mold shakeout time is greatly increased due to higher mold strength.
5) Cement cannot be reused and presents a disposal problem.
6) The cement molding process lacks the flexibility of the sand molding process for work speedup.

RAW MATERIALS

Scrap propellers (worn out or badly damaged) are commonly used in making up part of the furnace charge when casting new manganese bronze propellers. Such a practice aids the manufacturer in reducing cost and, if carefully controlled, does not detract from the quality of the casting produced.

It will be many years before a sufficient quantity of nickel aluminum castings will be available for scrap purposes. Therefore, from the outset rigid raw material requirements were set up for the ingot metal. For example, the use of scrap material for manufacturing nickel aluminum bronze ingots was prohibited. Only in this way could the presence of contaminating elements which could affect mechanical properties, casting quality and weldability be prevented. Ingot metal comprises all of the heat except for overmelt, gates and risers.

It is not advisable to use thin skulls and flashings such as those pulled from the ladle or runner box as they readily oxidize and contribute to the difficulty in melting. For the same reason it is poor practice to use any dirty or dross-covered material, or to melt in a furnace which has not been thoroughly cleaned of other metals. Occasionally when a charge is found lower in aluminum than desired, a master alloy containing the required additions may be added with the charge. When it is found necessary to adjust the composition of charged gates and risers which have lost aluminum during a previous meltdown, a master alloy containing the required additions may be added with the charge.

FEEDING OF PRODUCTION CASTINGS

Up to this point the discussion has revolved around melting, materials and metal handling. In continuing, the feeding operation will be considered, as it is perhaps the most difficult one of all in the casting of large nickel aluminum bronze propellers.

It became quite obvious during early investigations that feeding practices employed for small castings were not applicable to large nickel aluminum bronze propellers, nor was it possible to use manganese bronze practices for nickel aluminum bronze. To fully understand the situation, it is necessary to familiarize the reader with the general method of casting a manganese bronze propeller. This pertains only to those castings weighing in excess of 50,000 lb. The practice for smaller castings is generally less complex and cumbersome.

Metal from the ladle is poured into the runner basin containing a flow control valve. Larger castings require two ladles (Fig. 5). When the basin is full, the valve is opened and metal flows through the down and ingate to the base of the hub. Pouring is continued until the hub is filled and metal reaches between 6 and 12 in. into the riser. This distance is dependent upon the size of the casting and the dimensions of the riser. Metal approximately 100 F-150 F (38 C-65 C) hotter than the original pour is then added to the riser through a separate riser gate. The riser is insulated with a sleeve and cover of permeable casting plaster.[9]

Fig. 5 — Pouring a nickel aluminum bronze propeller casting from two ladles, necessary because of the casting size. When the basin is full the valve is opened and metal flows through the down and ingate to the base of the hub.

The insulating riser sleeve is a relatively new development, and has done an effective job in satisfying the conditions for adequate feeding. By preventing rapid heat loss, a liquid reservoir of molten metal is retained above the casting for a considerable period of time. Although other materials are available for this purpose, plaster has the advantages of being comparatively low in cost and simple to fabricate.

Directional Solidification

The above method of bottom pouring a casting would at first appear to be contrary to the fundamental principle of directional solidification. However, this is not the case. Most propeller designs are conducive to good directional solidification as the hub section is tapered and cast with the large end up. The massive surface area of the blades (the developed surface area of a 32,000 ton tanker propeller is approximately 27,000 sq in.) tends to dissipate heat rapidly and reduce time required for complete solidification of the casting. This in turn materially reduces the burden on the riser.

The large hot metal addition which is made to the insulated riser aids in setting up a temperature differential necessary for proper feeding. With all this, however, we must still contend with the fact that after the mold is filled the hottest metal is at the bottom, exclusive of course of hot metal which may have been added to the riser. This condition must reverse itself before solidification is complete otherwise the casting would contain shrinkage defects.

An experiment was made to determine the nature of the temperature reversal by placing thermocouples in the hub and riser of a manganese bronze Liberty ship propeller casting (rough cast weight of 27,000 lb) and plotting a time-temperature curve after the mold was filled. Figures 6 and 7 show the time-temperature curve and thermocouple positions for this propeller, and are a demonstration of the behavior, temperature-wise of manganese bronze when it is poured into a dry sand mold. Under parallel conditions all bottom poured castings of any material must have a similar cooling pattern.

The casting of a nickel aluminum bronze propeller is essentially the same as for the manganese bronze described above. As for the melting operation, there are also certain factors which tend to complicate the casting operation. First of all, unlike manganese bronze, the nickel aluminum alloy absorbs gas during melting. It has previously been shown by experimental work that it is possible to produce sound castings having acceptable mechanical properties from gassed metal, providing the gas content is not above a tolerable level and the rate of solidification is rapid enough to keep the gas in solution.

It can be appreciated that this latter condition is most difficult to control in the size castings under discussion. The emphasis must, therefore, be on the best possible melting practice to minimize gas absorption, and on an adequate degassing technique prior to pouring which will bring to the mold a metal of relatively low gas content. This is most important as excessively gassed metal will not feed, especially when the volume of metal involved is large and the solidification rate is spread over a long period of time.

Exothermic Reaction

Secondly, insulating plaster sleeves which had been successfully employed for manganese bronze, cannot be used for nickel aluminum bronze, as the higher pouring temperature of 2080 F-2130 F (1138 C-1166 C) causes an exothermic reaction with the plaster resulting in a violent boiling action which gases the riser metal. During the experimental program this fact was not obvious because the small casting cooled too rapidly for this reaction to take place.

Riser sleeves made from perlite, diatomaceous earth or other insulating materials, have been used with

some degree of success as these materials do not react at high temperatures. Lower insulating values are obtained from dry sand and cement sleeves, and make these materials less desirable.

Exothermic sleeves or pads are only partially effective in increasing feeding efficiency. When large castings are poured, the exothermic reaction takes place during the first few minutes after pour and the riser metal temperature increase at this time is marked from 50 F-150 F (10 C-65 C). This heat is rapidly dissipated, and by the time the casting requires liquid metal from the riser, the influence of the exothermic reaction is not available.

Some manufacturers of exothermic compounds supply their material in a number of grades of varying sensitivity. None, however, supplies grades with sufficient time delay for this application. Propellers such as the super-tanker class (28,000-100,000 ton tankers) require from 8-18 hr for complete solidification to take place. The only benefit such castings can obtain from these materials is from the insulation given by the burned out sleeve. Equally effective results can be obtained from much less costly materials. However, smaller castings which will completely solidify within a few hours can be materially aided by exothermic compounds. (Fig. 8).

Drossing and Nuclei Effect. Because of the drossing tendency of the subject alloy, it is most important that a gating system be designed to minimize the amount of turbulence developed during the pouring operation. Unsuccessful attempts were made to inert the mold with carbon dioxide to prevent the formation of dross during the pour. When the

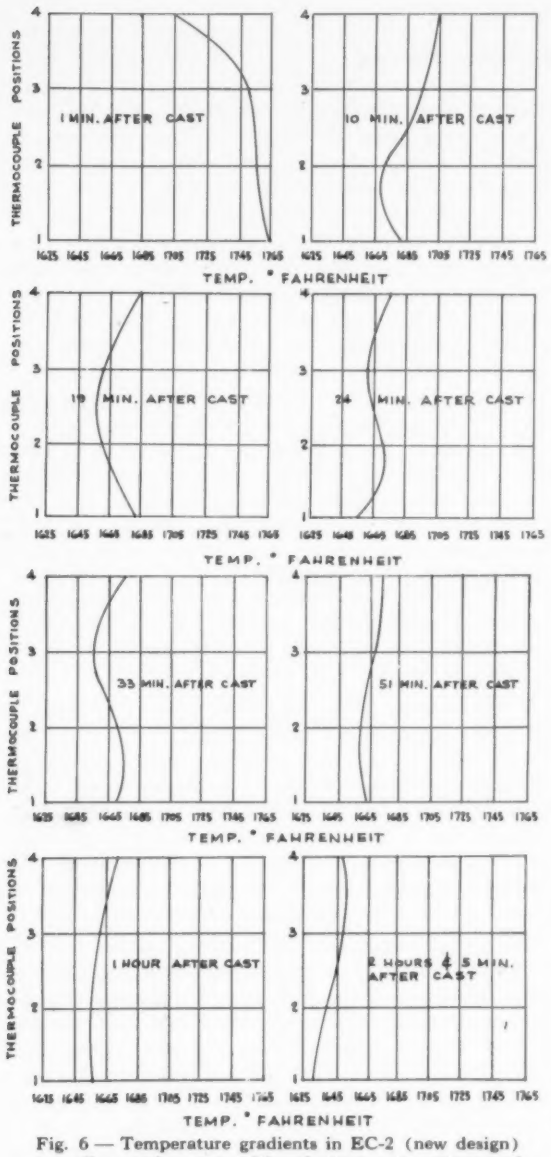

THERMOCOUPLE POSITIONS
1 MIN. AFTER CAST
10 MIN. AFTER CAST
19 MIN. AFTER CAST
24 MIN. AFTER CAST
33 MIN. AFTER CAST
51 MIN. AFTER CAST
1 HOUR AFTER CAST
2 HOURS & 5 MIN. AFTER CAST
TEMP. ° FAHRENHEIT

Fig. 6 — Temperature gradients in EC-2 (new design) propeller casting, cast with a bottom gate system and riser top filled with hot metal. Figure 7 shows the positions of the four thermocouples.

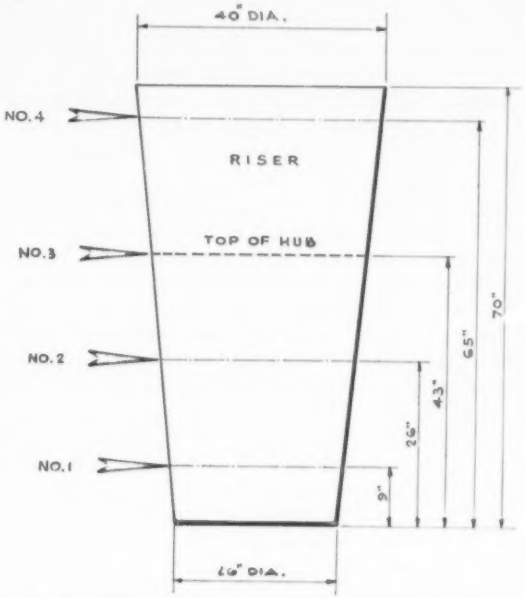
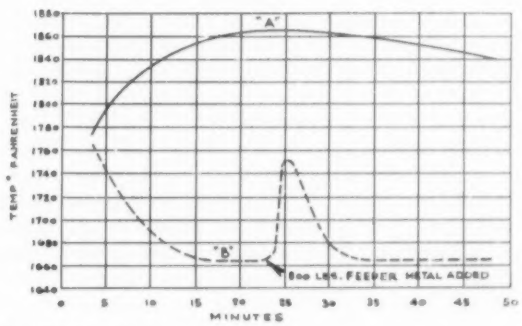


Fig. 7 — Details of positions of thermocouples in EC-2 propeller casting (Fig. 6). Thermocouples inserted into hub 5 in. from outside surface.



A – Exothermic sleeve and cover.
B – Dry gravel; plaster cover.

Fig. 8 — Time-temperature curves showing the rate of cooling in the risers of identical small manganese bronze propeller castings.

molten metal entered the base of the hub the heat caused the rapid elimination of the carbon dioxide, and the mold became for all practical purposes instantly filled with air. It was concluded that unless the mold could be made from an impermeable material and sealed inerting was a practical impossibility.

When the pour is complete and the metal has reached the top of the riser it is advisable to remove this dross to prevent its acting as a nucleus for further solidification. The problem is not a serious one for manganese bronze but from observing many nickel aluminum bronze castings, solidification progresses rapidly around this material. Unless it is removed the top surface is likely to freeze over and retard feeding. The job of removing this scum is difficult and unpleasant, and danger is always present that more will be formed if the work is not done quickly.

Pouring Temperature. Pouring temperatures which are not overly critical for manganese bronze must be closely regulated for nickel aluminum bronze. Higher metal temperatures aggravate the gas problem and result in greater shrinkage. With higher temperatures the mold loses some of its ability to chill the metal. On the other hand, temperatures must be high enough so that the metal fills the blade cavity without causing cold shuts.

The extremes of pouring temperature requirements must be met when it is considered that casting dimensions vary from approximately 1 in. thick at the blade tip to 15 in. thick in the hub section. A compromise temperature of approximately 2100 F (1150 C) appears to satisfy both of these requirements reasonably well, although shrinkage in the hub section would be more easily controlled with lower pouring temperatures.

Shrinkage Characteristics. The volumetric shrinkage of nickel aluminum bronze does not differ appreciably from that of manganese bronze, both being reported by various sources at anywhere from 6-10 per cent. It has been suggested that a peculiar formation of the primary dendrites which first freeze inhibit the gravitational flow of liquid metal. The previously mentioned possibility of gas coming out of solution would have the same effect.

Little or no solidification range exists for either of these materials as the liquidus and solidus are not separated by more than a few degrees. However, nickel aluminum bronze appears to have considerably less fluidity in this narrow range than does manganese bronze, obviously a contributing factor to the difficulty of feeding this alloy.

Chills. Although external chills judiciously placed in a mold have been successfully used by foundrymen for many years, the use of air or water cooled chills has been confined to relatively few applications. Because of the mechanics and obvious danger involved, other less satisfactory methods of promoting directional solidification have been employed. Large marine propeller castings, however, require a special application. A chill for castings of this size would have to be prohibitively large to be effective or it would require internal cooling so that it could maintain its effectiveness as a chill.

It is appreciated that the use of any kind of chill no matter how effective would have a questionable influence upon a propeller hub of the dimensions discussed here. For example, once the initial layer of metal solidifies and contracts from the chill could any further chilling action take place? It is conceivable that such a condition would render the chill completely ineffective due to the existence of an insulating air space between the casting and the chill.

However, it was decided to make a direct comparison of the influence of such a chill upon the rate of solidification of a large casting by pouring two identical propellers under closely controlled conditions and plotting a time-temperature curve on each. Because the practice for manganese bronze propellers was considerably more standardized and involved fewer variables, it was decided to run the comparison on this material.

Dry Sand Molding

Two five-bladed 32,000 ton tanker propellers were production molded in dry sand. During molding four thermocouples were inserted 5 in. into the hub. It would have been more desirable to insert the thermocouples into the mid-wall but this could not be done without subsequent major repairs to the casting. At the base of the hub, mold A contained a cast iron chill having a 1 in. diameter spiral copper coil. Crow foot connectors on each of the protruding ends of the pipe allowed for water inlet and outlet lines. Mold B, intended for the control casting, was identical except that no chill was employed.

Furnace capacity does not allow the pouring of two such castings on the same day, but the foundry was successful in maintaining approximately the same pouring temperatures and chemical compositions for each on different days. Water at full line pressure (75 - 85 lb/sq in.) was allowed to flow through the chill in mold A as soon as metal reached the base of the hub, and temperatures were recorded at 5 min intervals for 400 min. The same recording procedure was used for mold B. A comparison of each thermocouple location is shown in Figs. 9 and 10.

These time-temperature curves aptly demonstrate the effectiveness of the water cooled chill which had a most immediate influence on the lower portion of the propeller hub. Within 15 min the temperature began dropping at a comparatively rapid rate. This was not felt at the 21 in. location for 104 min, but at 170 min the chilled casting at this location had cooled to 1515 F (824 C). The nonchilled casting required 400 min to cool to this temperature.

With directional solidification progressing at such a rate, it becomes most important that the chill show some influence at the junction of the riser and the casting (located 48 in. from the bottom). Here the temperature break occurred at 252 min and reached solidification a short time later. The nonchilled casting was still in a liquid, mushy stage at the end of 400 min, and still depended upon the riser for feeding. Temperature measurements taken in the riser show the short-lived temperature influence of relatively small feeder additions.

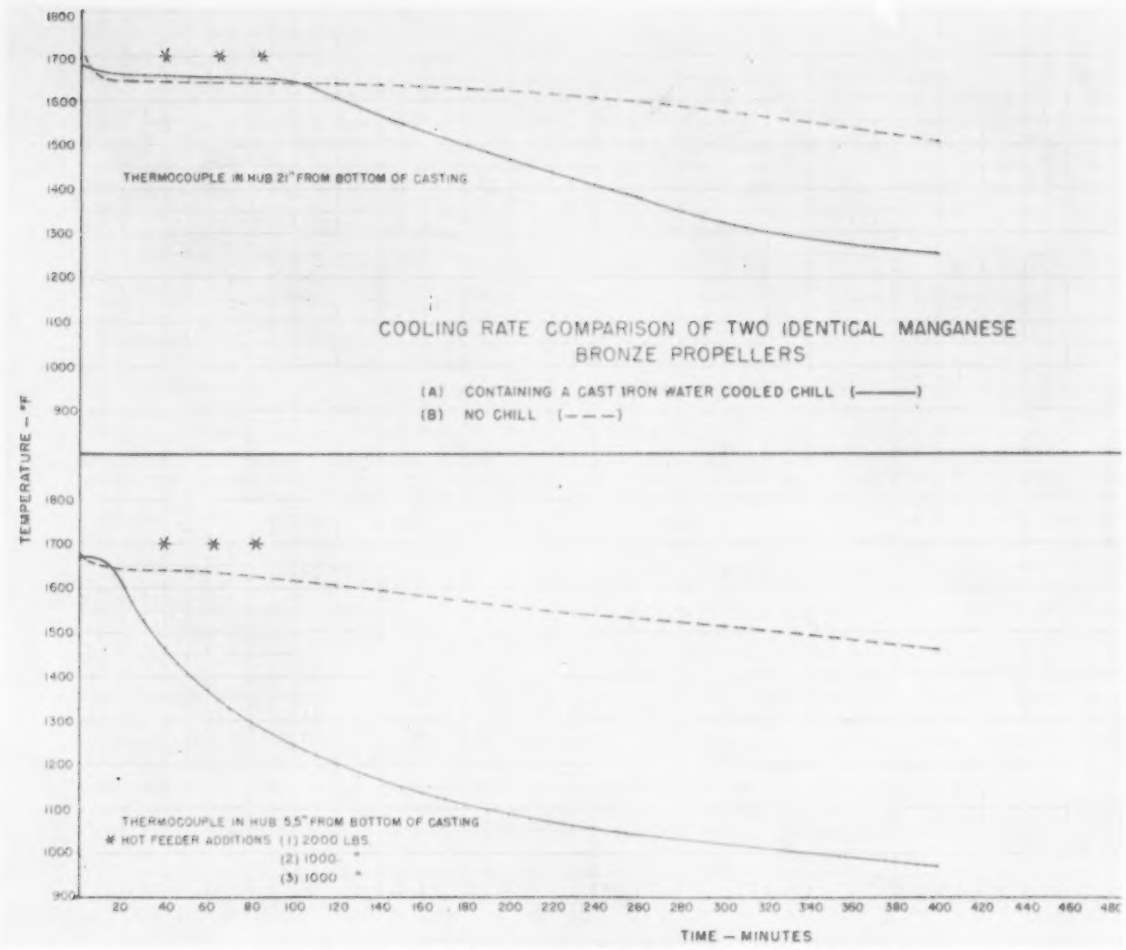

COOLING RATE COMPARISON OF TWO IDENTICAL MANGANESE BRONZE PROPELLERS
(A) CONTAINING A CAST IRON WATER COOLED CHILL (———)
(B) NO CHILL (— — —)
THERMOCOUPLE IN HUB 2½" FROM BOTTOM OF CASTING
THERMOCOUPLE IN HUB 5.5" FROM BOTTOM OF CASTING
* HOT FEEDER ADDITIONS (1) 2000 LBS.
(2) 1000 "
(3) 1000 "
TEMPERATURE — °F
TIME — MINUTES

Fig. 9 — Cooling rate comparison of two identical manganese bronze propellers.

Although the above direct comparison was not repeated for nickel aluminum bronze propellers, the water cooled chill was successfully used for this material. Temperatures were taken of the chill during the casting period for both nickel aluminum bronze and manganese bronze and the time-temperature curves are shown in Fig. 11. The higher temperature reached by the chill for the nickel aluminum bronze casting is explained by the higher pouring temperature. The rather sudden temperature drop of this chill at 190 min is due to an increase of water pressure at this point.

The results of the above tests show that water cooled chills can be used effectively to decrease the solidification time for a large casting.

Although the chill is not necessary to produce sound manganese bronze castings it will enable the foundryman to increase his yield by reducing the riser volume, and improve his casting quality by promoting greater density in the heavy sections. Its advantages are more apparent, however, when applied to nickel aluminum bronze. By promoting more rapid solidification there is a greater likelihood of the ever present gas being retained in solution. If gas does come out of solution, as it is more likely to, the metal above will be more liquid (due to the shorter time it remains in the liquid state) and the gas can more readily pass through to the riser. The burden on the riser is materially reduced as it is not required to remain fluid for an unusually long period.

The effectiveness of a chill is in its ability to stay well below the metal temperature so that it is capable of rapid heat transfer. Gas, steam or air could also be used to cool the chill but there would be a marked decrease in efficiency. The latter has been employed at the foundry but results were less satisfactory than with water.

Undoubtedly it is possible to design a better chill than that described here. For example, high conductivity copper with an irregular surface would be more effective than gray iron with a flat surface such as that employed in the subject chill.

Some may question the value of a chill which reduces the solidification time to "x" numbers of hours, and admittedly this is still a long period of time for metal to remain in the liquid or mush state. It cannot be disputed, however, that halving the solidification time normally required is an appreciable speeding up of the process. It also follows that directional solidification is more certain, and the benefits derived

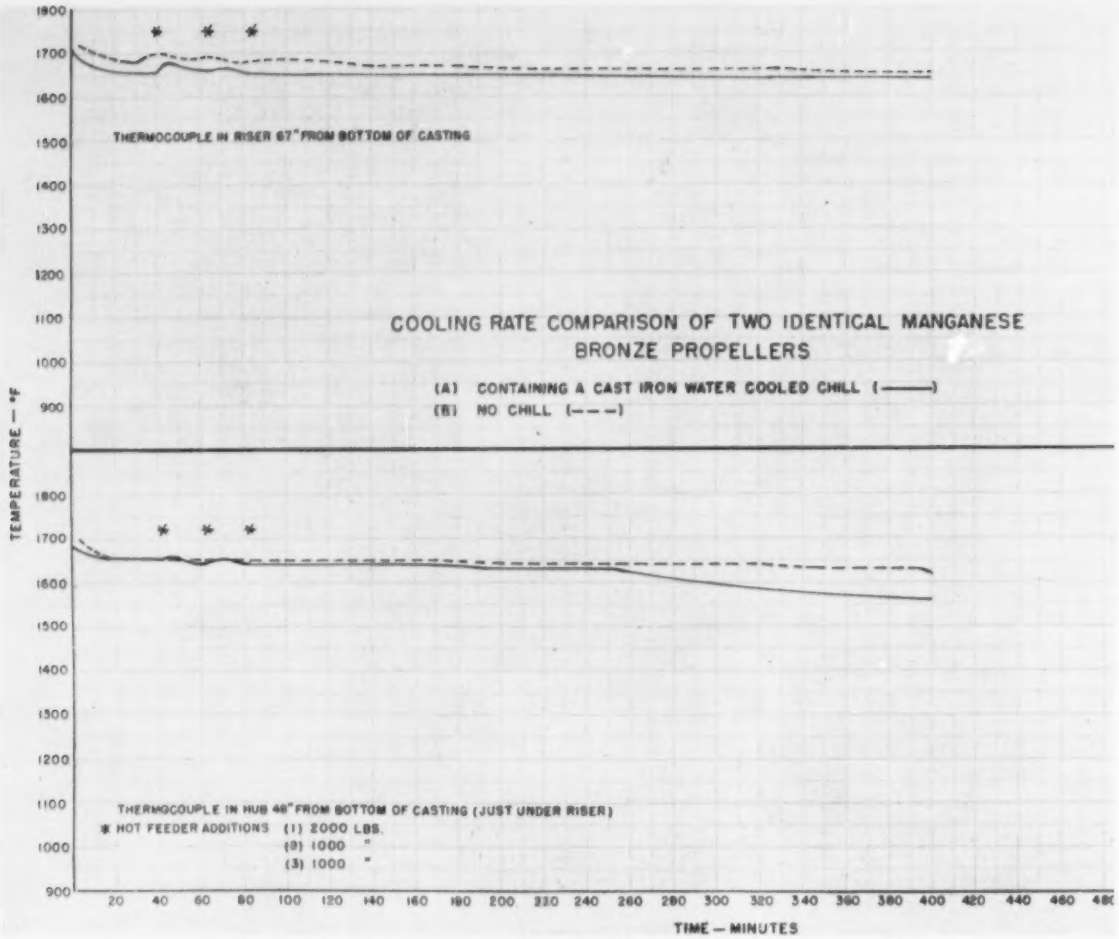

COOLING RATE COMPARISON OF TWO IDENTICAL MANGANESE BRONZE PROPELLERS
(A) CONTAINING A CAST IRON WATER COOLED CHILL (———)
(B) NO CHILL (– – –)
THERMOCOUPLE IN RISER 67" FROM BOTTOM OF CASTING
THERMOCOUPLE IN HUB 48" FROM BOTTOM OF CASTING (JUST UNDER RISER)
* HOT FEEDER ADDITIONS (1) 2000 LBS.
(2) 1000 "
(3) 1000 "
TEMPERATURE — °F
TIME — MINUTES

Fig. 10 — Cooling rate comparison of two identical manganese bronze propellers.

by the casting are quite positive. It is concluded that water cooled chills do work for the application noted.

There are admittedly certain disadvantages attached to the use of the water cooled chill which make it somewhat unattractive to the specialty jobbing shop. A variety of chill sizes is required to effectively cover the range of castings produced by a given foundry. They can be made interchangeable up to a point, but for full effectiveness the chill must be in complete contact with the base of the casting. Then there is the ever present danger of water under a mold full of liquid metal. The successful application of the water cooled chill does not allow for the human error.

A COMPARISON OF NICKEL ALUMINUM BRONZE AND MANGANESE BRONZE

Although this paper is primarily intended to present the general foundry problems involved in a new alloy development, it seems fitting to present a comparison of the old and new alloys with regard to service data and engineering properties obtained within the past few years.

Comparative data on chemical composition, mechanical properties and erosion-corrosion resistance are shown in Table 1. Further erosion-corrosion test data are shown in Figs. 12a and 12b.

Uniformity. Mechanical properties of a nickel aluminum bronze propeller casting are best represented by values of separately cast test bars. Tests made on this material show that only minor variations in properties exist from light to heavy sections of the casting. Manganese bronze lighter sections almost always exhibit properties superior to those of the heavy sections.

The composition of nickel aluminum bronze is responsible for its greater resistance to fouling by marine growth.

Comparative Service Data. The superiority of nickel aluminum bronze has been convincingly demonstrated by an in-service test. One propeller of each material was installed on a twin screw 6,000 ton ore carrier which subjects its wheels to unusually severe service by operating on the Orinoco River in Venezuela. The sand bars and sand in suspension in this river are responsible for damage to the ship's propellers, necessitating frequent reconditioning or replacement. For the past three years, at 6 month intervals these propellers have been examined in drydock. The nickel aluminum bronze (starboard) propeller

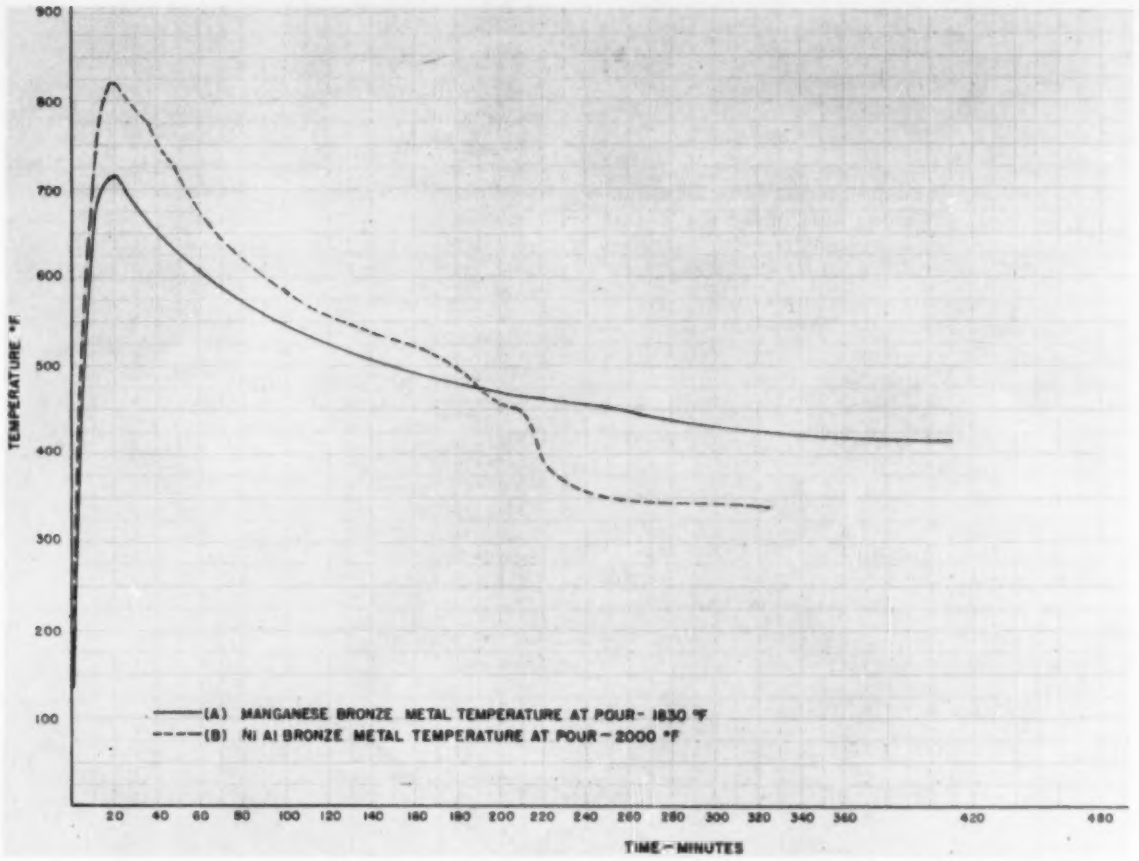


Fig. 11 — Time-temperature curve of cast iron water cooled chill in the base of propeller mold.

has suffered little mechanical damage or erosion, while the manganese bronze (port) propeller was rather severely damaged and required frequent repair. This program of comparing two different propeller materials under actual service conditions is continuing.

Two large high-speed, ocean-going luxury liners have nickel aluminum bronze propellers on one ship and manganese bronze on the other. Runs are similar in all respects. Notable fuel savings have been made on the ship with the nickel aluminum bronze propellers.

The U.S. Navy is using this material for propellers for ice-breaking service, and after a full season of operation excellent results were noted.

Other service follow-ups on nickel aluminum bronze propellers, although not on a direct comparison basis, have shown excellent wear characteristics. No service failures have been reported since these propellers were first put into service in 1954.

Propeller Efficiency. Less obvious perhaps than the data presented in Table 1, but more important from a service standpoint, is propeller efficiency. The design engineers at the author's company are most impressed by the ability of nickel aluminum bronze to retain its original smooth machined surface over a long period of time, thereby retaining its high efficiency factor. Numerically the improvement in efficiency would lie in the order of 1.5-3.0 per cent, with resultant fuel savings. The exact efficiency increase would depend upon the propeller size, design factors and length of service.

Design Benefit. As nickel aluminum bronze is in itself approximately 10 per cent lighter in weight than manganese bronze, and can be designed to thinner sections because of its higher strength, other advantages become apparent. For example, loading stresses on the tailshaft and bearings are reduced, thus permitting smaller shafts.

Resistance to Notch Sensitivity. The ability of nickel aluminum bronze to resist failure under impact when notched contributes greatly to its value as a propeller material.

A series of standard nickel aluminum bronze propeller material samples was submitted to an independent laboratory for notch sensitivity and impact tests. The general results of such tests can be summarized as follows: A brittle weld bead was used for purposes of developing a sharp crack in the test samples. Despite the presence of this crack, the material refused to break in tests at temperatures as low as −170 F (−112 C). This would indicate that the material is not susceptible to brittle fracture of the cleavage failure type.

Maintenance. Maintenance of nickel aluminum

bronze propellers under identical service conditions is greatly reduced compared to that of manganese bronze. Its superior resistance to bending, breaking and wearing, including cavitation is directly associated with the chemical and mechanical properties of the material.

Reparability. Nickel aluminum bronze is readily reparable with the inert gas process. Little or no preheat is required, and unlike the copper zinc brasses, it is not subject to stress corrosion cracking and therefore does not necessarily require a stress relief treatment. Normally repairs can be made with either the solid or stranded aluminum bronze wires. Excellent results have recently been reported with a high manganese nickel aluminum bronze wire. The straightening of propeller blades must be done at temperatures in excess of 1400 F (760 C) to avoid cracking in the brittle range.

Propeller Cost. Reduced weight of nickel aluminum bronze in conjunction with increased strength of the material allows designing the propeller approximately 18 per cent less in weight than a comparable manganese bronze propeller. Although the former is more costly by the price per pound, the long term cost reduction is appreciable.

OTHER APPLICATIONS OF NICKEL ALUMINUM BRONZE

Although this paper is primarily concerned with nickel aluminum bronze as a superior propeller alloy, its use is in no way confined to any specific engineering application. Utilization of nickel aluminum bronze has extended into almost all fields[10] where its superior strength, wear resistance and comparatively low density can be effectively realized. Industries such as aeronautical, tool and die, marine, electrical and chemical are currently employing this new material.

SUMMARY

Increased service requirements of the new higher horsepower ships of the post-war period established the need for a new propeller alloy. This paper presents a general review of some of the foundry problems involved in developing a casting practice for nickel aluminum bronze. The material was selected as the alloy having the best combination of wear resistance, mechanical properties and foundry handling qualities. However, many problems arose before an acceptable casting practice was developed. Some of the findings regarding these problems are outlined here.

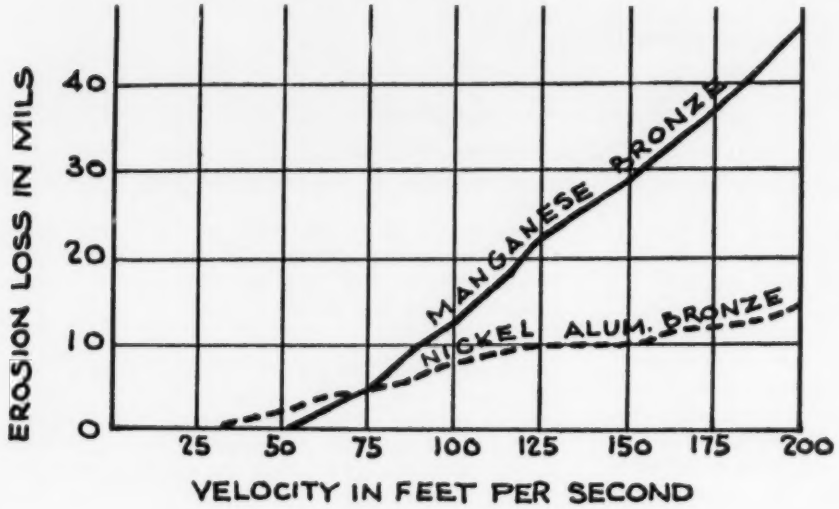


Fig. 12a — The measured erosion losses on 8 in. discs spun for 500 hr at a peripheral velocity of 200 ft per sec.

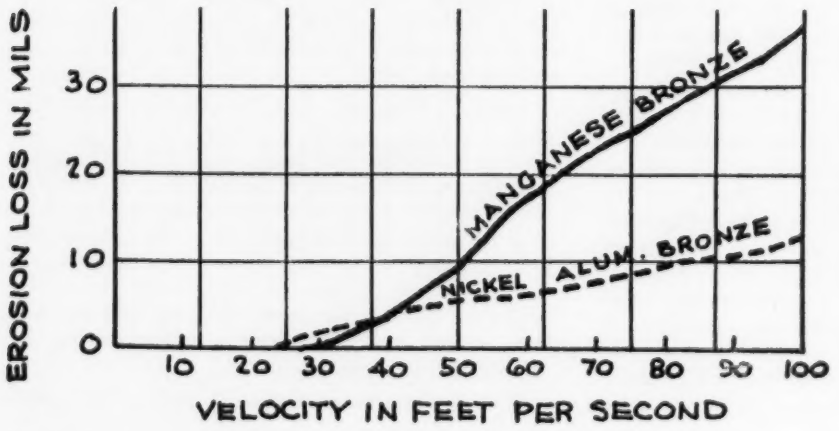


Fig. 12b — The measured erosion losses on 8 in. bronze discs spun for 500 hr at a peripheral velocity of 100 ft per sec.

Fig. 13 — A rough cast nickel aluminum bronze propeller for a 32,650 ton tanker.

1. Melting Practice

a) It was found necessary to move the burner flame closer to the metal bath to prevent excessive oxidation of aluminum and to obtain faster meltdowns.

b) Close control of the combustion atmosphere was required to prevent excessive gas (hydrogen) absorption and oxidation.

c) It was found essential that raw materials be controlled by rigid specifications.

2. Gas Absorption

a) Gas was absorbed by metal melted in all types of melting equipment tested but was most pronounced in reverberatory furnaces.

b) The reduced pressure tester was utilized to establish the presence of gas in the molten metal.

c) Excessive gassing of the metal markedly reduces the mechanical properties and results in serious casting defects by hindering the feeding operation.

d) Gas pickup could not be avoided entirely but could be reduced to a comparatively harmless level by flushing with an inert gas.

3. Molding Methods and Materials

The conventional molding methods and materials (baked gravel sand) used at the author's company presented no particular problem in the casting of this alloy. Cement bonded sands were also investigated.

4. Refractories

There is an apparent need for high grade refractories at reasonable cost.

5. Fluxes

Fluxes were successfully employed in crucible furnaces but hindered the melting operation when used in the reverberatory furnaces.

6. Feeding

The most difficult problem in the production of nickel aluminum bronze was feeding the propeller casting. Plaster insulating riser sleeves could not be used due to the high temperatures involved. Exothermic riser materials, although satisfactory for small castings have limited use on the larger castings because of the long period required for complete solidification.

Water cooled chills were successfully used to promote directional solidification in large propeller castings and materially reduced the time required for complete solidification to take place.

7. Pouring Temperature

For nickel aluminum bronze of low gas content, pouring temperature has no appreciable influence upon mechanical properties.

8. Advantages of Nickel Aluminum Bronze

Although manganese bronze is still the most widely used propeller alloy and continues to give acceptable service for slower propulsion machinery, nickel

aluminum bronze is rapidly gaining in popularity throughout the shipbuilding industry. Comparative service tests under identical conditions of operation have placed nickel aluminum bronze in a favorable light. Some of the advantages of this new alloy are made obvious by comparing its mechanical properties with those of manganese bronze. Other less obvious advantages are:

a) Propeller efficiency is retained over a long period of time due to its resistance to surface roughening. This efficiency increase results in marked fuel savings.
b) Because of its lower density and higher strength, a nickel aluminum bronze propeller can be made approximately 18 per cent lighter in weight than a comparable manganese bronze propeller. This reduces the loading stresses on the tailshaft and bearings, thereby permitting smaller shafts.
c) The material has comparatively low notch sensitivity.
d) Although the nickel aluminum bronze alloy is more costly by the price per pound, its long term cost is lower than manganese bronze.
e) Nickel aluminum bronze propellers require less maintenance than manganese bronze propellers.

ACKNOWLEDGMENTS

The author has recorded some aspects of a development program which entailed the cooperative efforts and hard work of many people. Particular reference is made to P. Ffield, Bethlehem Steel Co., F. L. LaQue, J. S. Vanick and G. Lee of The International Nickel Co. for their early aid and encouragement of this program and for their continuing interest in this field. L. M. Mosher, Bethlehem Steel Co., Shipbuilding Div., contributed greatly to this program by his erosion-corrosion studies and in-service follow-up of propeller alloys. E. R. Miller, Foundry Supt. at Bethlehem Steel Co. Staten Island Foundry and his staff exhibited great persistence and skill in successfully carrying out this program. J. Fitzgibbon of Whitehead Metal Products Co. successfully stimulated early interest in the nickel bronzes for propellers. A. J. Krug, Met. Chemist and Asst. to the author aided in putting together this paper.

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PRACTICAL PLANNING FOR NON-DESTRUCTIVE TESTING BY USE OF RADIATION

By F. S. Sutherland

ABSTRACT

The general problems concerning non-destructive testing by radiation are considered. The problems discussed are:

1) Choice of source or unit.

2) Exposure room design.

3) Protective materials.

4) Fixed and portable sources.

5) Employee considerations.

The three testing units described are the 250 kv x-ray, the 1000 or 2000 kv x-ray and the betatron.

When a company decides to accept orders for a product which will require x-raying, what procedure should be followed? If the company is located in a large urban area where industrial x-ray facilities are available, it may choose to use these facilities, until the extensiveness of this program has been decided as well as its future possibilities.

If the company is not located in a community where the necessary facilities are available, or believes it would be more advantageous to install its own x-ray department, then there are several problems to consider. It is the purpose of this paper to point out some of these problems.

In general, the problems fall in three main categories. 1) The selection of personnel to perform the work, 2) the source of radiation and 3) the protection of those who will work with radiation equipment for radiation is no respecter of persons.

EMPLOYEE SELECTION

The number of employees required will depend on several factors, such as:

1) Type of equipment obtained.
2) Volume of work.
3) Rapidity of exposure time.
4) Conditions under which work must be performed.

For example, a crew of three will be sufficient where exposure time is approximately 3 min and four to 10 radiographs are taken per hour. Two employees for positioning the films and source, and the third employee in the darkroom.

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The employee selected to be responsible for results should be capable of exercising ingenuity as many technical problems will arise when a variety of castings are submitted. He should have some knowledge of which part of a casting is more susceptible to defects, and how to bring out the defect to best advantage on a radiograph. He should have some knowledge of darkroom technique. Good darkroom procedures make it possible to avoid a lot of retakes.

The employee responsible for the operation should be able to train those working with him. He should see that no employee in the plant is exposed to excessive radiation. If electrical equipment is used, this employee, or some maintenance employee, should become sufficiently familiar with the installation so as to maintain it in proper working order and make minor repairs.

CHOICE OF SOURCE OR UNIT

The most common equipment used in radiographing metal in foundries are:

1) Portable capsule 250 kv-x-ray.
2) 1000 or 2000 kv-x-ray.
3) Betatron.

These are commonly referred to as a pill – a 250 (1), million volt or 2 million volt (2) and 24 million betatron (3) (Figs. 1,2,3).

One or more of the above units will generally accomplish the work encountered in foundries. In order to acquaint those who have not had experience

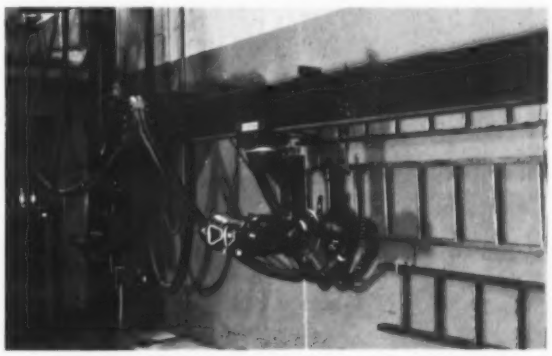


Fig. 1— A 250 kv x-ray unit, showing braces used for support.

in x-ray with the problems involved, a brief general discussion is given.

The choice of unit will depend on the kind of metal, the metal thickness and the amount of work to be performed in a given period of time. For example, a small unit may be sufficient for the metal thickness involved, but the exposure time will be too long for the number of pieces per turn. A larger unit could reduce the exposure time to one-fifth that of the smaller unit, and the work all performed on one turn. Also, continued use of a unit for long exposures frequently increases the maintenance costs. A small unit may also be idle time for the x-ray crew unless an extra setup room is provided, as exposure time mounts rapidly on a small unit. Figure 4 gives some idea of the time required for various metal sections with different sources of radiation.

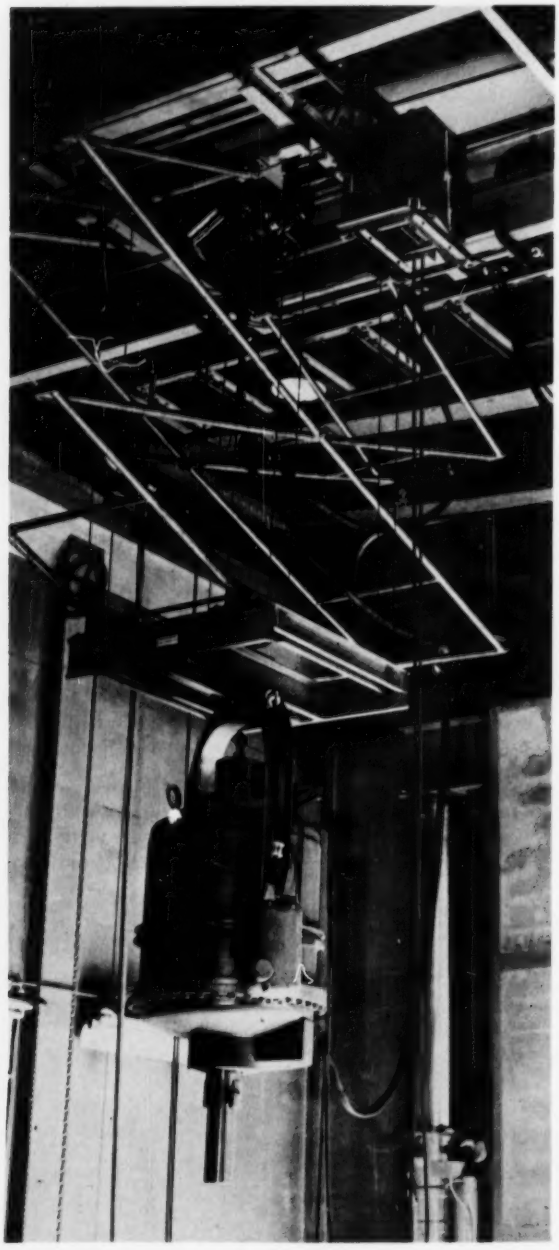


Fig. 2 — A million-volt x-ray unit, showing pantagraph supports.

LOCATION

The location of a given-size unit will determine the type and amount of protection required. If the unit is isolated, then only the operating personnel and film storage need be protected. If the unit is located in a building where other employees are working, then protection must be adequate for all possible exposures. Remember that radiation can radiate in all directions, and should employees be working above or below this room they must be protected. The craneman who may have to pass overhead cannot be overlooked. The more powerful the unit, the more protection that is necessary. The suppliers of the unit can give a great deal of advice and information concerning protection, and also check the installation for weak spots.

DESIGN

Considerable thought should be given to the design of the layout, for mistakes are expensive to rectify. A compact exposure room will be less expensive to build, but insufficient room may necessitate rebuilding at a later date. An L-shaped room can save a lot of expense on door protection. It is wise to visit some other installations and get ideas before proceeding.

The operating panel should not be built into a wall without access to both sides by maintenance

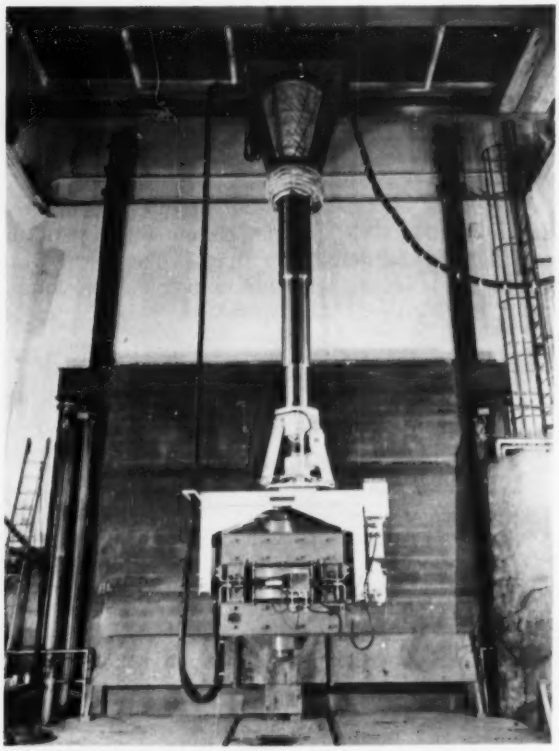


Fig. 3 — A betatron unit, showing crane arrangement.

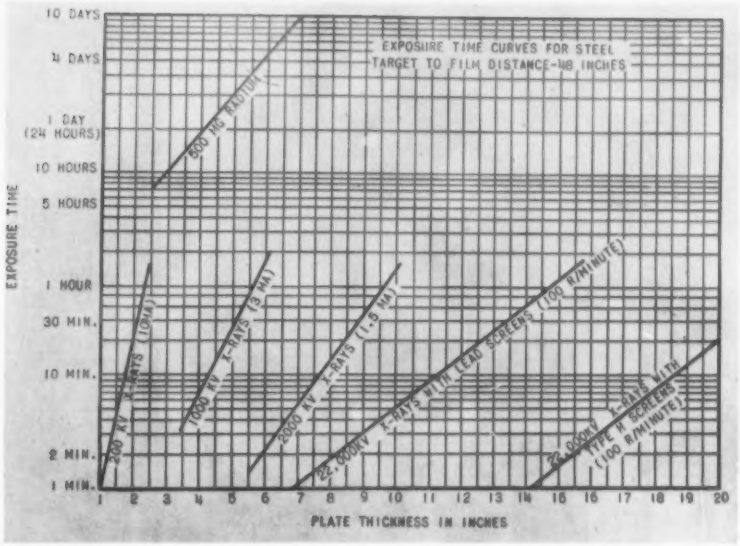


Fig. 4 — Graph showing time required for various metal sections with different sources of radiation.

men (Fig. 5). Wherever the panel is located, this dual accessibility is necessary. This is also true of the dark room developing tanks (Fig. 6). Figure 7 shows a simple design that is functional, compact and planned so that an excessive amount of walking is unnecessary. The electrical and plumbing facilities are accessible to the maintenance crew (Fig. 8).

Work may be delivered through an ordinary door or interlock door at the work entrance by truck or transfer car. Castings may be temporarily stored in this area if the workroom is congested. An overhead crane may be used to transfer the castings to the radiographic area. This crane may travel on the same track that carries the support of the x-ray equipment. The wall thickness around the x-ray room is determined by the size of the unit and construction material.

If the number of items to be x-rayed are numerous and the exposure time short, a preparation room may be advantageous, as a setup may be completed on a car while other exposures are being made. Cars can then be exchanged and the process continued. The volume of work can almost be doubled by this procedure. Also, the radiation room can be made smaller and the expense for protective material reduced.

PROTECTIVE MATERIALS

The most common protective materials for radiation room are lead, steel and concrete. One in. of lead is equivalent to approximately 4 in. of steel or 12 in. of concrete. Combinations of these materials may be used to advantage.

As mentioned previously, if the building is isolated, preferably in a fenced enclosure, then only the operating personnel and film storage need protection. The roof and the three side walls may need little, if any, protection. If the unit is located in a one-story building where there are other employees, then protection for the 4 walls must be supplied. If there are workers above or below the radiation room, then additional protection is necessary. Again, the

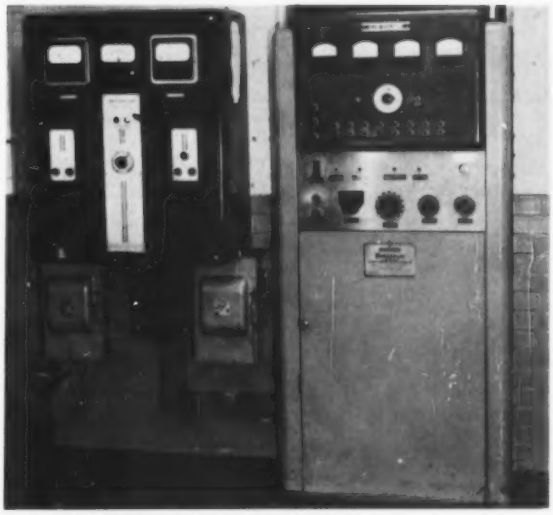


Fig. 5 — Method of installing an instrument panel for x-ray and betatron units, built into the wall in such a way that the panel can be repaired from both sides by maintenance men.

Fig. 6 — One type of darkroom arrangement. The drying cabinet opens out into the viewing room.

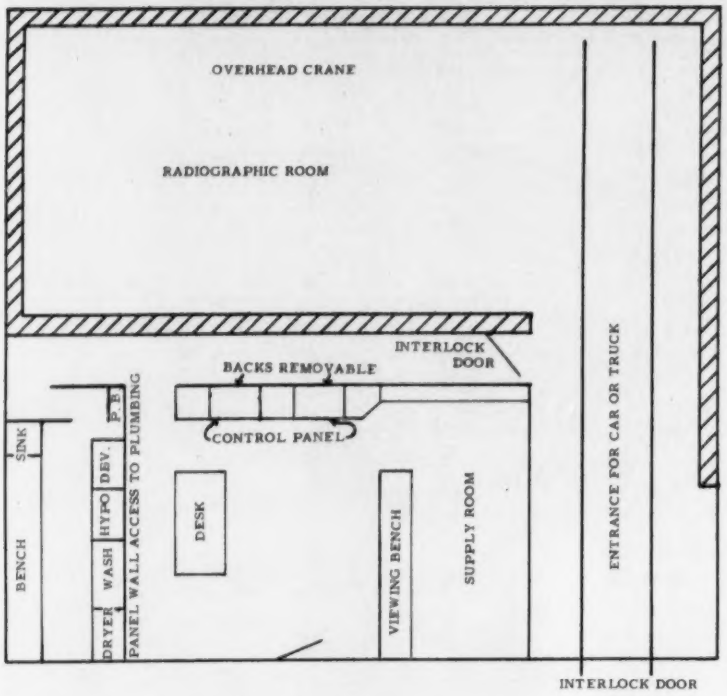


Fig. 7 — A simple, functional design for an x-ray building that is compact, and planned so that an excessive amount of walking is unnecessary.

supplier of the unit can be of assistance as to amount of protection required for a particular unit.

It may be mentioned here that some state laws endeavor to control this protection, and a company must comply to the satisfaction of an inspector.

Frequently, the building design includes a protective passageway between the radiation room and the control room.

A right-angle exit to the radiation room will serve as protection to a point close to the exit. Both walls, however, should have sufficient protection. Tests should be made in the passageway for scatter, with the unit in operation in various parts of the radiation room. X-ray units will give a great deal more scatter than a betatron due to the character of the beam.

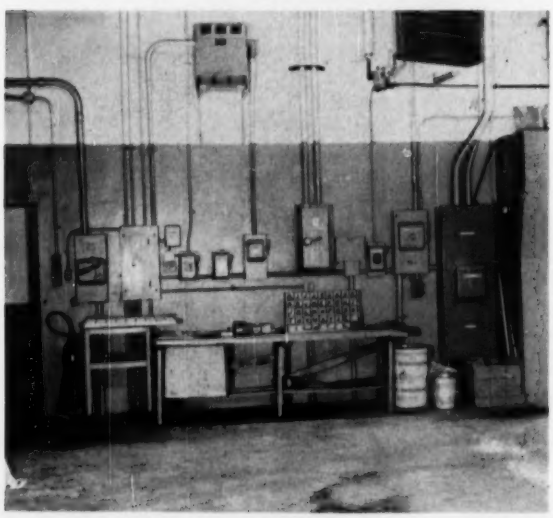


Fig. 8 — Example of installation of electric switches located near a door so they are handy in case of electrical fire. This is an important consideration in designing an x-ray building.

FIXED SOURCES

Fixed energy sources usually refer to x-ray (Fig. 9) and betatron installations (Fig. 10) to which the material to be tested must be brought. These units are generally mounted on a crane, and can be positioned up and down, forward and reverse and in a revolving motion. The unit, however, is confined to one building. An auxiliary crane is generally provided for handling the castings, as these units are for heavy metal sections.

Included in this class are the million and two million volts x-ray and the betatron. For protection here, 18 in.-72 in. concrete walls are used on all parts where employees may be adjacent. By the use of steel or lead sheets as inserts or linings, the wall thickness may be reduced. Consult your supplier of equipment to be certain your protection is adequate. The installation should be thoroughly checked with the units in various positions. On the smaller x-ray machines, the protection can be modified considerably and the expense reduced. Since this equipment is much lighter, it may be hung from an arm or other light crane. If a great number of small castings are to be handled, some kind of positioner will expedite the amount of work which can be performed, and space saved, all of which cut protection costs.

PORTABLE SOURCES

Generally, portable sources include x-ray units up to 250 kv, and various types of radium and cobalt capsules. For these units, there are numerous variations in protection. If the capsule is removed from a

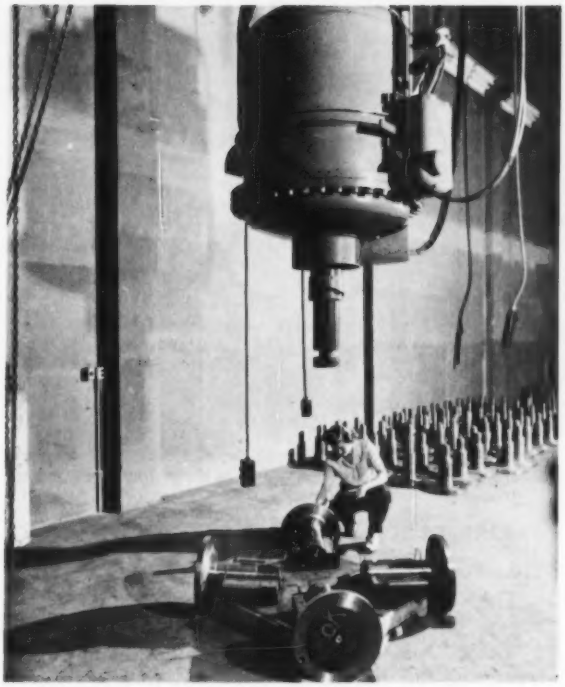


Fig. 9 — A million-volt x-ray unit, showing a four shot arrangement. Four castings are arranged for radiographing, using only one exposure. The controls for positioning the unit are seen in the foreground.

safety container, precautions must be taken by all personnel. Usually, the occasion is out in the plant some place, and distance is about the only safety factor that can be employed. The capsule can be handled by a long pole such as a fishing rod. This permits pulling the capsule up to end of the rod and then removing the rod during exposure. Roping off the area and placing warning signs on all sides should provide protection for other employees. This procedure permits the accomplishment of several exposures at one time by setting castings in a circle around the capsule (Fig. 11).

Where individual shots are required, there are various types of equipment which are available to provide protection. Capsules are enclosed in a container, with an opening for exposures. Portable x-ray units of various sizes also are available, both mounted and unmounted. In these, protection is provided for the employee performing the work. However, the problem of protection for other employees is still necessary. Here, again, distance is often the only protection available.

At this point, it should be mentioned that intensity of the radiation is inversely proportional to the square of the distance. It is therefore apparent that reasonable protection can be attained by making a given area out of bounds to all personnel.

Where a direct beam is employed, a steel or lead screen can also be employed for additional protection when the operation is confined to a limited space. It should be remembered that radiation, however weak, is accumulative, and continued exposure should be prevented. Individual checks are always

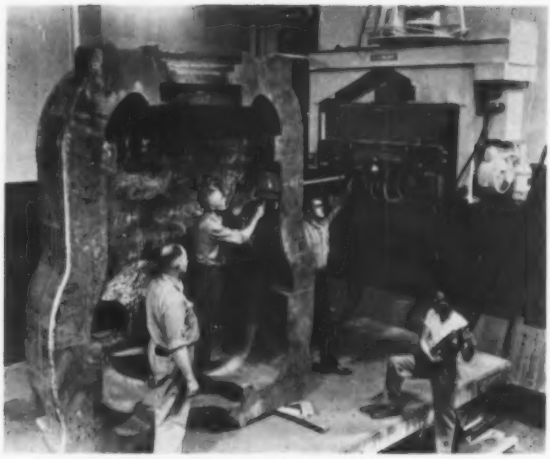


Fig. 10 — A large steam turbin casting, metal 16 in. thick, set up for radiographing by betatron.

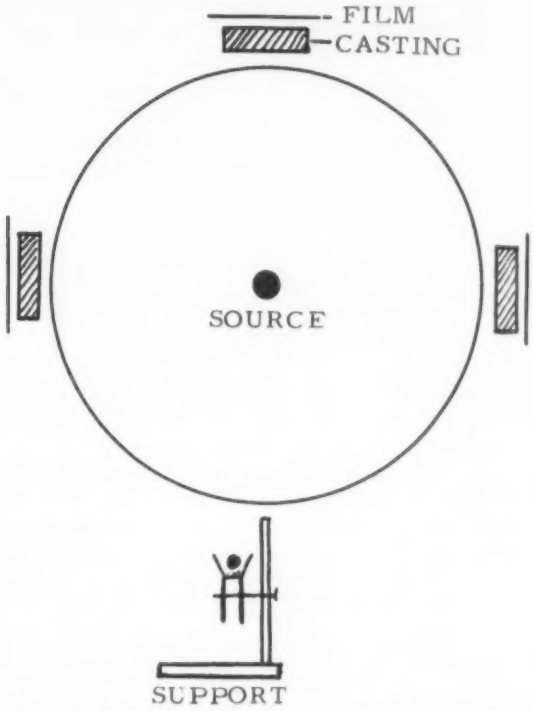


Fig. 11 — Method of setting castings in a circle around the capsule so several exposures can be made at one time.

advisable. This may be accomplished by a pencil-shaped dosimeter made for this purpose and worn by the employees. Also, the badge system can be used for weekly checks. This badge contains a sensitive film which is developed by the supplier and read for intensity of accumulation, and serves as a record if a question of liability arises.

Also, periodic blood or urine analysis should be employed as a record of employee's physical condition. These records are valuable in determining any general trend in blood condition. The application of these tests will be determined by the plant doctor.

MODERN QUENCHING OILS AND TECHNIQUES FOR FOUNDRY HEAT TREATING

By N. F. Squire

ABSTRACT

The increasing importance of, and variables affecting, the quenching phase of heat-treating steels is discussed. The conventional quench, marquench and modified marquench are dealt with, giving pertinent data for each. Case histories showing results of using an additive-type quenching oil medium are presented.

With the increased demand for heat-treated castings having physical properties not obtainable by annealing, normalizing or homogenizing, many foundries are installing new heat-treating facilities utilizing liquid quenching.

Foundries not previously engaged in this type of heat treating will find that the quality control standards for heat treatment of wrought steel parts have become more rigid in recent years, and will be equally rigid for castings.

It is no longer sufficient for parts simply to be hardened. Because of high processing costs, castings must be clean, have good machinability, a minimum of distortion and, in addition, maximum physical properties and fatigue life.

The quenching phase of heat treating plays an increasingly important part in meeting these rigid standards, especially in leveling out the many variables with which the heat treater must contend.

The American Society of Metals states this very adequately in the *Metals Handbook*, p. 615:

> "The purpose of quenching steel generally is to produce a completely martensitic structure on the surface of the piece to be hardened (a minimum requirement) or in the center of the piece (a maximum requirement). Hardening implies the formation of martensite, which, before tempering, provides the highest hardness obtainable in a steel of low alloy content. This hardness is directly related to carbon content.
>
> "If the hardening is incomplete, that is, if some pearlite or ferrite is present, usually the mechanical properties will be inferior to those of a completely martensitic steel, even though both are tempered at the same hardness. Accordingly, when highest mechanical properties are required, quenching must be controlled with precision.
>
> "Whether or not satisfactory hardening is achieved, depends upon the composition and structure of the steel, the shape of the piece, and relation between size and section, as well as on the composition of the quenching medium. Because of the complex relations among all of these variables, few of which can be expressed quantitatively, hardening remains largely an art. However, failures during hardening can be minimized by recognition of a few well-established relations among hardening variables."

N. F. SQUIRE is Vice Pres., Aldridge Industrial Oils, Inc., Cleveland.

VARIABLES

Time-Temperature Factor

The variables mentioned apply to castings as well as to conventional parts made from bar stock or forgings. One of the most critical variables in determining the quenching media required is the time-temperature factor of both composition and structure.

The difference between shallow hardening and deep hardening of steel is the cooling rate required through a critical temperature zone of approximately 1200 F - 800 F (649 C - 427 C) so a completely martensitic structure can be obtained and undesirable transformations avoided.

An available publication shows the time-temperature-transformation curves of many casting compositions as well as wrought steels. In this publication if the curves for any particular casting composition are not shown, the curves for similar wrought steel compositions can be used as a guide as their quenching reaction will be the same.

Variations in the T-T-T factor are shown in Figs. 1 and 2.

Figure 1 is for a Society of Automotive Engineers 1080 steel. These curves are typical of the straight carbon steels. A fast cooling rate is required down to a temperature of approximately 600 F (316 C) to avoid upper transformations to undesirable ferrite and bainite.

The T T-T curves in Fig. 2 are for a S.A.E. 4340 steel. They illustrate the effect of alloy composition in increasing the allowable cooling time to obtain a full transformation to martensite.

Transformation curves for the majority of production-type steels will fall somewhere between the curves in Figs. 1 and 2.

Section Thickness

Another variable affecting transformation is section thickness. As the thickness increases the cooling time increases. Also, density of the load in a batch-type furnace has a similar effect unless the velocity of the quenching media (agitation) is sufficiently high to offset the retarding effect of the sectional thickness.

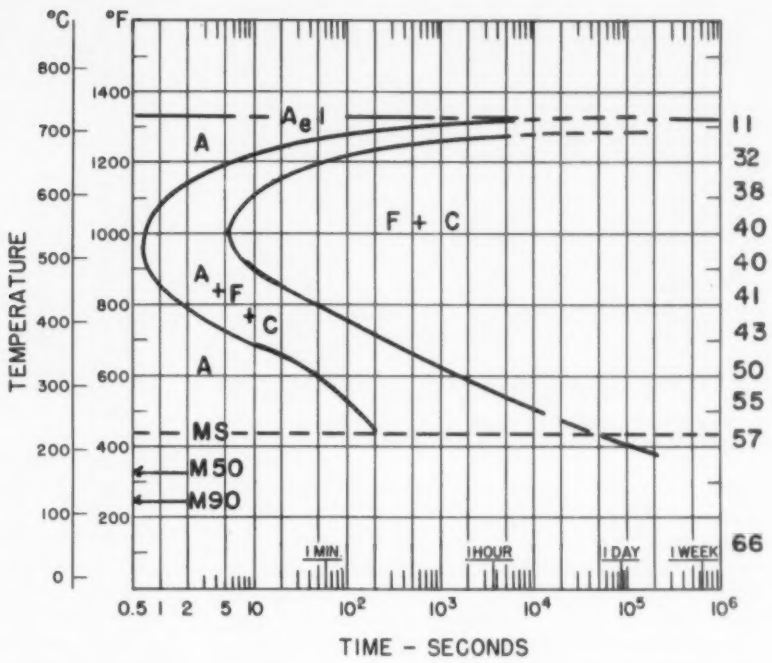


Fig. 1 — Transformation curves for a S.AE. 1080 steel, with alloy elements — C-0.79 per cent and Mn-0.76 per cent, austenitized at 1550 F (843 C). Grain size — 6.

To meet the problems imposed by steel composition variables – grain size, geometry and section – three types of quenching are used. They are generally known as the conventional quench (Fig. 3), the martemper quench (Fig. 4) and the modified marquench (Fig. 5).

CONVENTIONAL QUENCH

This quench (Fig. 3) is the most commonly used, and may employ water, brine, caustic or oil as the quenching medium. The quenching medium temperature ranges from 70 F - 100 F (21 C - 38 C) for the water-type media, and from 125 F - 170 F (52 C - 77 C) for oil. The selection of one of these quenching media requires careful consideration. In the majority of applications where it is necessary to process a variety of steel compositions, oil is the more generally used quenching medium. Oil is more suitable for a wide range of steel compositions as it causes less distortion and cracking. Oil can be

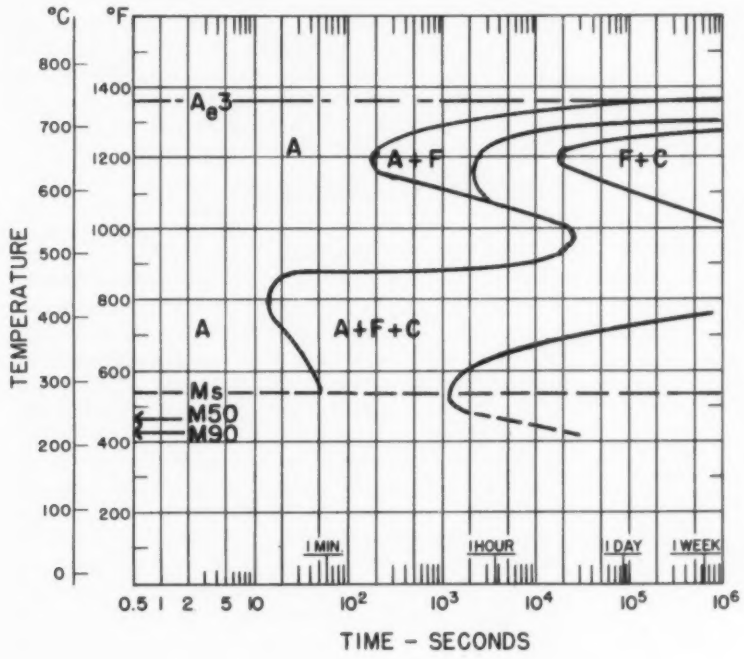


Fig. 2 — Transformation curves for a S.A.E. 4340 steel, with alloy elements — C-0.42 per cent, Mo-0.33 per cent, Ni-1.79 per cent, Mn-0.78 per cent and Cr-0.80 per cent, austenitized at 1550 F (843 C). Grain size — 7-8.

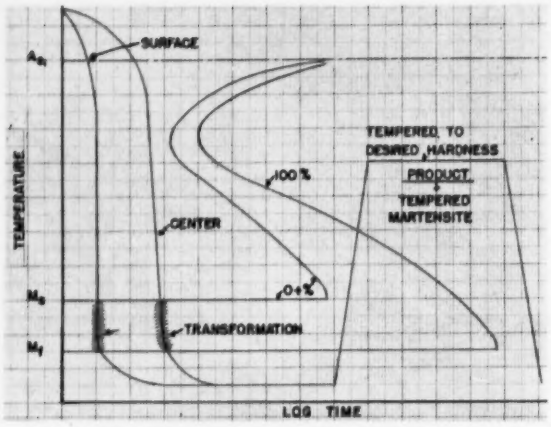


Fig. 3 — Conventional quench and tempering curves used to meet problems of steel variables.

used at higher temperatures thereby reducing the degree of thermal shock.

Oil being the more versatile quenching medium has encouraged considerable investigation and development in recent years to further increase its quenching power, operating temperature range and stability for long service. One additive for quenching oil with which the author has worked is a proprietary additive that, when added in proper ratio to selected quenching oils, has the ability to approximately double the cooling power of the quenching oil from 1550 to 700 F (843 to 371 C). At 700 F (371 C) the rate of cooling reduces rapidly. This is a desirable feature since it permits more equalization of temperature between the core and surface of the work before complete hardness is obtained.

Case History

A comparison of Brinell hardness readings before and after the use of the quenching oil additive is shown in Table 1. Increased cooling power was obtained with the additive, with a resulting increase in quenching out hardness. A wide range of diameter of bar stock was used for the three alloy compositions at this company.

The bar stock was heat-treated for machinability by a commercial heat-treating company. The "Before" hardness was obtained with the quenching oil in regular use at the company. The "After" hardness was obtained after the additive was used in the existing conventional quenching oil. No other changes were made in equipment or agitation.

TABLE 1 — BRINELL HARDNESS READING COMPARISON

	S.A.E. 4140		S.A.E. 4150			S.A.E. 4340	
Size in.	Bhn Before	Bhn After	Bhn Before	Bhn After	Size in.	Bhn Before	Bhn After
1	429	495	477	555	1½ x 3	477	534
1½	415	495	477	578	2 x 4	429	487
2½	415	477	461	534	3 x 7	387	444
3	401	444	444	495			
5	388	444	444	514			
7	388	444	415	495			
8	375	429	388	444			

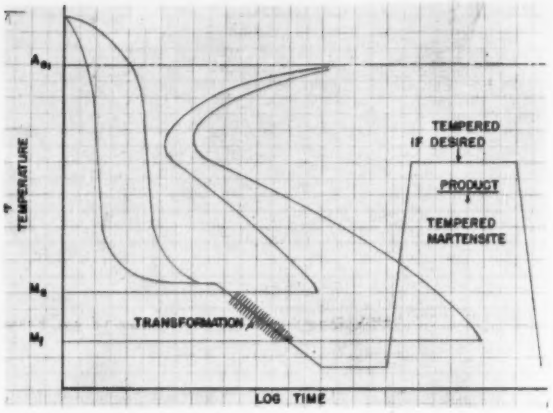


Fig. 4 — Marquenching curves for steel.

Draw temperatures had to be increased from 100 to 125 F (38 to 52 C) over those previously used in order to temper to the required hardness. This greatly improved machinability.

These comparisons (Table 1) demonstrate that although agitation is extremely important, agitation alone does not compensate for the difference in cooling power of quenching oils. The table also shows the effect of section thickness on the obtainable quenched-out hardness.

MARQUENCHING

Figure 4 shows marquenching which is used primarily when control of distortion is of major importance. Because of the high temperature of the quenching medium required in this process, salt is usually used. The cooling power of fused salt is somewhat less than oil, therefore, marquenching in salt may be limited by the composition of the steel and the size of the part. Where the temperature of the bath must be 400 F (204 C) or above, salt must be used as a quenching medium due to the short life of oil at this temperature. Where the temperature of the bath is 350 F (177 C) or lower, oil is a better quenching medium due to the poor fluidity of salt in this temperature range.

MODIFIED MARQUENCHING

Figure 5 shows modified marquenching, the most recently adopted quenching procedure. This is one process that promises to be the most versatile and effective in meeting today's rigid heat-treating requirements. Modified marquenching employs the use of a fast quench oil as the quenching medium in a temperature range between 200 F - 300 F (93 C - 149 C), but usually between 225 F - 260 F (107 C - 127 C).

In this temperature range, control of distortion has been comparable to regular marquenching and hardness is greatly improved. Many of the late model batch-type furnaces and some of the continuous-type furnaces are equipped with immersion heaters for accurate control of the oil temperature. Also, many existing quenching tanks have been converted to modified marquenching at low cost by the use of immersion heaters, steam coils or radiant tubes.

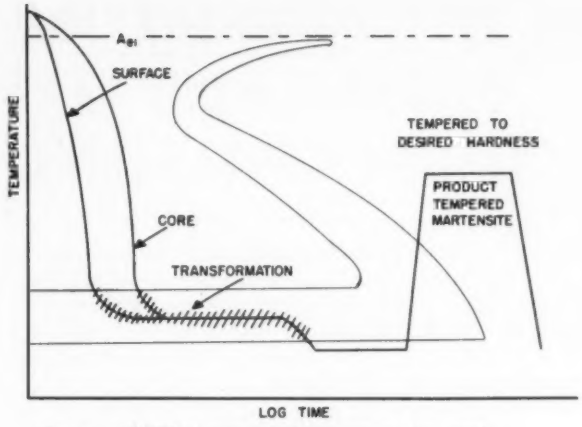


Fig. 5 — Modified marquenching curves for steel.

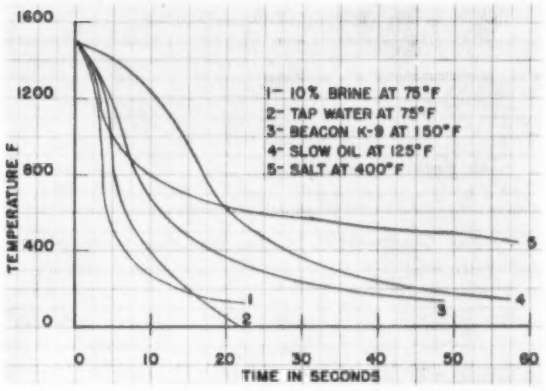


Fig. 6 — Cooling curves for a metal immersed in different quench media.

Control of oil temperature is always important for the best quenching results in either the conventional quench or modified marquench.

What, then, is the most ideal quench to offset the many variables with which the heat treater must contend, and yet produce maximum physical properties and dimensional control? It has been said, and correctly so, that the ideal quench is one which has high cooling power in the initial or early portion of the quench and a slow cooling rate in the lower temperature range.

Figure 6 shows the cooling curves of metal immersed in all the quenching media previously mentioned. The water and brine media have the highest initial cooling speed, but continue to cool rapidly throughout lower temperature ranges where distortion and cracking usually occur. This is why they are generally used for shallow hardening steels, simple geometries or large, heavy cross-sections.

Conventional quenching oils have a much slower cooling rate both in the initial and intermediate range, but the cooling power is not adequate to obtain maximum hardness in the straight carbon steels and some of the lean alloy steels, except with light sections. However, the slower cooling in the lower temperature range will permit a more gradual transition, and have less tendency to cause distortion and cracking than water or brine.

Additive-Type Oils

The additive-type quenching oils for the conventional quench, or for the modified marquench have high cooling power in the initial and intermediate range sufficient to miss the nose of the T-T-T curves on most compositions of steel. In the lower temperature range, the cooling rate is sufficiently slow to permit gradual transition to martensite, thereby producing maximum hardness with a minimum of distortion.

The most common misconception of fast quenching oils has been that they will cause more distortion and cracking than a slow quenching oil, the reasoning being that since we get more distortion and cracking with water, any quenching media which make steel harder will produce similar results.

This is not a fact, because a fast quenching oil having better wetting action reduces the vapor-phase portion of the quench. This causes more even cooling in the initial portion of the quench and reduces stresses that are caused by vapor pockets.

In the lower temperature range where water or any water composition quenching media continues to cool rapidly, fast quenching oils cool more slowly and permit better equalization of temperature between light and heavy sections before transformation is completed.

Agitation of a quenching medium is important regardless of which medium is being used. Violent agitation produced either by high capacity pumps or propellers, if properly directed, can greatly increase the cooling power of any medium. This is especially important when using fast quenching oils. Because of the ability of fast quenching oils to extract heat more rapidly, the hot oil must be moved away from the surface of the work and distributed throughout the quenching bath. A practical study of proper agitation that can be adapted to almost any quenching facility can be found in the booklet *Improved Quenching of Steel by Propeller Agitation*, published by the United States Steel Corp.

A fast, additive-type quenching oil, operating in an oil temperature range of 200 F - 300 F (93 C - 149 C) with adequate agitation, has proved to be a combination which has offset the majority of the variables with which the heat treater has to contend. While it obviously does not eliminate all of the problems, it has improved the quality control beyond any point that has previously been attained.

A second case history shows how many variables have been offset by this method. This company is a large automobile parts plant making steering gears. A steering gear shaft of S.A.E. 6120 steel carburized was quenching out with a spotty hardness and excessive distortion.

The automotive gears were on shafts of from 1¼ - 1⅜ in. diameter by 5 - 7 in. long. The gears were carburized for 12 hr in a surface combustion furnace, loaded vertically in trays and quenched directly through a protective atmosphere at 100 F (38 C) in their regular quenching oil.

TABLE 2 – TYPICAL ROCKWELL HARDNESS READINGS

Gear No.	Rockwell C Hardness
1	51-54-49-54
2	41-48-48-46
3	49-51-61-54
4	42-43-58-49
5	40-45-60-48
6	51-41-58-45

Typical Rockwell C hardness readings taken from the shaft 90 F (32 C) apart for six gears are shown in Table 2.

Changes had been made in the furnaces, agitation and processes used for these gears. The only way the company was able to get satisfactory hardness was to lay the parts on their sides, but this caused distortion of the gears which exceeded the passable limits.

The plant metallurgist decided that the vapors created when the hot trays and parts hit the quenching oil at 1650 F (899 C) were the cause of the nonuniform hardness readings. To offset this, the proprietary additive concentrate previously mentioned was added to the oil already in the furnace. The effects of the vapor phase of quenching was reduced, and the Rockwell C hardness readings were increased, as shown in Table 3.

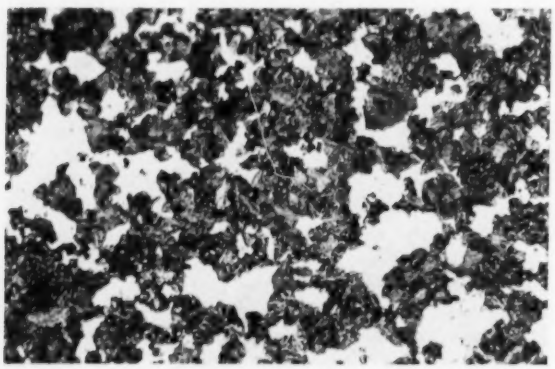


Fig. 7 — Bainitic microstructure (structure at surface is untempered martensite with nodular troostite) of automobile steering gear shaft made of a S.A.E. 6120 steel carburized and conventional quenched. Hardness ranged from 40-61 Rockwell C. 500 ×.

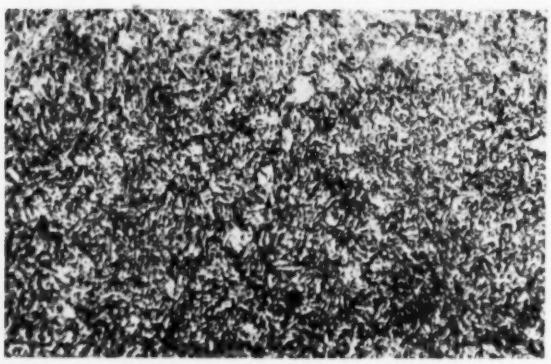


Fig. 8 — Martensitic (100 per cent) microstructure of automobile steering gear shaft made of a S.A.E. 6120 steel carburized and quenched with additive in quenching oil. Hardness ranged from 63-66 Rockwell C. 500 ×.

TABLE 3 – ROCKWELL C HARDNESS AFTER ADDITIVE USE

Gear No.	Rockwell C Hardness
1	64-65-66-67
2	67-66-62-66
3	65-66-66-64
4	66-66-66-66
5	64-64-65-66
6	65-64-64-64

The hardness readings were taken at the same intervals as with the regular quenching oil. Twenty-two parts were tested, with a total of 88 tests being made. Of the 88 tests, 83 ranged from 64 - 67 Rockwell C hardness. The hardness did not drop lower than 62 in any of the tests.

The engineering department of the company has now set 58 Rockwell C hardness as the minimum acceptable to improve wearing surfaces of gears.

Figure 7 shows the type of microstructure (bainitic) which was being obtained with this company's conventional quench. The previously mentioned additive was put in the existing quenching oil with no other changes in procedure. Figure 8 shows the type of microstructure (martensitic) obtained with quenched-out hardness after using the additive.

With the uniformity of quenched-out hardness, inspection was reduced from a 100 per cent check to a spot check, and straightening costs in man-hours reduced by 75 per cent. Such savings are obviously far greater than the total cost of a quenching oil, the loss usually amounting to between 2 and 4 quarts drag out per ton of work heat treated.

SUMMARY

The benefits to be obtained by good quenching techniques may be summarized:

1) Economical service life of the quenching medium.
2) Uniform hardness pattern.
3) Elimination of undesirable transformation structures.
4) Development of optimum quenching conditions for steels of small or varying grain sizes, different hardenabilities and variable cross-sections.
5) Minimum dimensional changes.
6) Elimination of quenching cracks.

Contacts with heat-treating departments throughout the country show that there are many of them not taking advantage of improvements in equipment and quenching oils now available. In most cases, personnel responsible for heat treating recognize the benefits which can be obtained, but other branches of management that control appropriations are not familiar with heat treating or aware that heat treating has become a precision operation.

There are many case histories where improvements in equipment, or the adoption of a more efficient quenching oil, has eliminated re-runs and scrap in heat treating and reduced distortion with subsequent straightening costs, or permitted closer preliminary machining which reduced final grinding time thereby reducing processing costs in other operations.

MOLYBDENUM EFFECT ON GRAY IRON ELEVATED TEMPERATURE PROPERTIES

By G. K. Turnbull and J. F. Wallace

ABSTRACT

The effect of up to 2.0 per cent molybdenum on the short-time tensile and stress-rupture properties of a 3.8 per cent carbon equivalent gray iron has been determined by various additions of that alloy to two base irons: one with only residual alloys; and another containing approximately 0.60 per cent chromium. The gray iron was melted in a cupola, transferred to an electric arc furnace for holding and preheating, and alloyed as required by additions to the pouring ladles. The tests were performed on 0.505 in. diameter tensile specimens that were machined from 1.2 in. diameter bars cast in baked core sand molds. Short-time tensile tests were conducted at room temperature, 800, 1000 and 1200 F; the stress-rupture strength was measured for fracture times up to 100 hr at 800, 1000 and 1200 F.

Increasing molybdenum additions up to 2.0 per cent generally resulted in greatly improved high-temperature properties at all testing temperatures. Some decrease in short-time tensile strength occurred with the higher molybdenum irons, particularly those containing chromium, because of the presence of considerable massive cementite. The stress-rupture properties of the irons containing chromium were superior to the straight molybdenum irons for all compositions at 1200 F and for those irons with less than about 1.5 per cent molybdenum at 800 and 1000 F. The rupture strength of the higher molybdenum-chromium irons at 800 and 1000 F was reduced below the values for the comparable molybdenum irons, however, by the presence of massive cementite. Metallographic examination of the irons before and after the 100 hr stress-rupture testing indicated: some bainites were slightly decomposed at 800 F; all bainites were decomposed at 1000 F; and all bainites and pearlites were agglomerated and spheroidized at 1200 F.

INTRODUCTION

Current A.S.M.E. Codes limit the use of gray iron in unfired pressure vessels to 650 F for stressed applications. The problem of raising the allowable temperature limit for this material for load bearing parts has been of concern to the foundry industry.[1] More data on the high temperature properties of gray iron are required to provide the evidence necessary to encourage application of gray iron castings at higher temperatures.

G. K. TURNBULL is Rsch. Asst. and J. F. WALLACE is Assoc. Prof., Dept. of Met. Eng., Case Institute of Technology, Cleveland.

Available data for unalloyed gray iron show that the short-time high-temperature strength is reduced at temperatures in excess of 700 F.[2] However the decrease in short-time tensile strength does not appear rapid until the temperature exceeds 850 F.[3-7] In addition to the decrease in strength with temperatures, it has been shown that the modulus of elasticity of gray iron is decreased to some extent and the ductility increased slightly.[5-6]

The short-time high-temperature strength of gray irons is considerably improved by addition of alloys. Molybdenum and chromium are particularly effective in this respect.[4,6,7] In addition to increasing the room temperature strength,[2,8,9,10] these elements have a stabilizing effect on the combined carbon in the matrix and retard the rates of softening and of secondary graphitization.[2,7,10,11,12] In this manner, these elements also reduce growth of the cast iron at elevated temperatures.[2,12-16]

Creep and stress-rupture information are of considerably more importance than short-time tensile tests when applications involving extended elevated temperature exposure are considered. The creep rate of unalloyed gray iron at temperatures over 800 F is fairly high[2,7] compared to some other ferrous materials for use at high temperatures. The stress-rupture strength of unalloyed gray iron is also appreciably reduced by temperatures in excess of 800 F. Both creep and stress-rupture properties can be markedly improved by the addition of alloying elements, particularly molybdenum. It has been shown that molybdenum was the most effective alloying element for improving these high temperature properties of gray irons in a recent series of tests at 800 and 1000 F.[7] The beneficial influence of molybdenum on the stress-rupture properties of several gray irons has been shown for other work conducted at 750 F[6] and 800, 1000 and 1200 F.[9,17] Some of the results of this latter, heretofore unpublished work, are reported in this paper.

It has been shown in these references that increasing additions of molybdenum resulted in a steady improvement in high-temperature properties. The results were limited, however, and reported at scattered temperatures and for a wide variety of irons.

The investigation described in this report was undertaken to provide a detailed study of the effect of

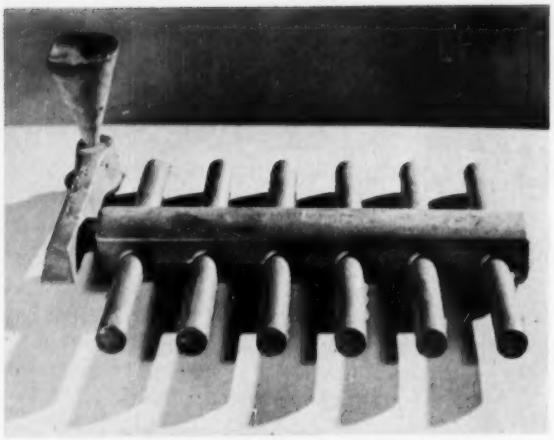


Fig. 1 — Cast coupons showing gating and risering.

molybdenum on the high temperature properties of irons of a similar type over the temperature range of greatest commercial interest, 800-1200 F. The base analyses and type of iron employed in this investigation were maintained at a reasonably constant level, and various amounts of molybdenum were added to these irons so that the effect of this element could be observed. A Class 40 gray iron was employed as the base composition. Molybdenum additions up to 2.5 per cent were made to two series of this iron: first, to the base iron; and second, to the base iron containing about 0.60 per cent chromium. The high temperature tests conducted on these irons were limited to short-time tensile tests and stress-rupture tests up to a fracture time of 100 hr.

PROCEDURE

The gray iron was melted in a cupola and then transferred to a direct electric-arc holding furnace for mixing and preheating. The molten iron was tapped from the electric furnace in weighed amounts into a ladle suspended on a scale. The additions of ferro-alloys and inoculants were made to the small ladle as the weight of molten metal required for each analysis was tapped. The temperature in the electric furnace was controlled at approximately 2800 F before tapping. The charge in the cupola consisted of steel and gray iron scrap, pig iron and dolomite, with small additions of ferrosilicon and ferromanganese. The constituents of the charge were selected to avoid alloy residuals. No additions were made to the electric furnace. Because of the large amount of metal required and limited capacity of the electric furnace (4000 lb), continual additions of molten metal were made to the furnace from the cupola holding ladle as required.

All compositions were inoculated during teeming from the electric furnace by additions to the stream of 0.30 per cent silicon as 85 per cent regular ferrosilicon (containing 1.5 per cent Al). Approximately 0.03 per cent carbon as electrolytic graphite was added to the stream on the composition containing over 1.5 per cent molybdenum. Some additions of mexican graphite were also made to the ladle spout on the compositions containing over 0.56 per cent molybdenum.

After preheating, alloying and inoculating, the molten iron was poured into horizontal molds produced from baked oil-bonded sand. The pouring temperature was approximately 2600 F. The test bars employed in this investigation were cast as 1.2 in. diameter, 6 in. long bars from a central runner that also served as a riser. The arrangement of 12 bars about this central runner-riser and the special gating system employed are shown in Fig. 1. The test bars were permitted to remain in the molds overnight (14 hr) before shakeout.

A considerable number of coupons were poured for each composition. It was desired to vary the molybdenum content in steps of 0, 0.25, 0.50, 0.75, 1.00, 1.50, 2.00 and 2.50 per cent in the base iron for one series and in the base iron containing 0.60 per cent chromium for the second series.

After shakeout, the coupons were broken from the riser and machined to standard 0.505 in. diameter threaded tensile bars with 2 in. gage lengths. The diameter of the gage section was slightly and gradually reduced at the center of the gage length to facilitate fracturing at the position where the lowest thermal gradient occurred. Bars from the three higher molybdenum analyses of the chromium series and the two higher molybdenum analyses of the plain series were annealed at 1400 F for 1½ hr before machining in order to soften the matrix to some extent. One bar from each series was employed for chemical analysis and another was split longitudinally through the center and etched for a determination of soundness. A hardness survey was taken along the length of this bar.

Short-time tensile tests were conducted on a 60,000 lb tensile machine. A three-coil electric resistance furnace was used in conjunction with an automatic controller to provide temperature control. Thermal gradients from the ends of the specimen to the center and thermal fluctuations during testing were measured with three thermocouples and held to ±5 F throughout the tests. After reaching the testing temperature, a 30 min stabilization period was permitted before loading was initiated.

Stress-rupture tests were conducted on two lever-arm machines of the dead-weight type, and a screw-type creep-rupture machine with a calibrated stiff spring operating a screw mechanism. All three machines were of the constant load type and varied only in their method of load application. Thermocouples were placed at the bottom, center and top of the gage length section of each specimen before heating. Temperature fluctuations and gradients were held to ±2 F. Before testing, a 30 min stabilization period was provided to permit the specimen to reach thermal equilibrium. The load was then applied and the time to fracture recorded.

Metallographic examination was employed to examine the "as cast" or annealed microstructure of each composition, and to observe the effect of holding under load for approximately 100 hr at each temperature. Tests from the cast and annealed specimens were removed from the center of the coupon. The metallographic specimens from the bars which ruptured after 100 hr were taken from a section perpen-

TABLE 1 – CHEMICAL ANALYSIS

% C	% Si	% Mn	% Mo	% Cr
	Straight Molybdenum Irons*			
3.22	1.88	0.78	0.05	0.16
3.32	1.78		0.22	
3.26	1.73		0.50	
3.28	1.84		0.76	
3.28	1.68		1.00	
3.09	1.82		1.54	
3.01	1.82		2.02	
3.03	1.78		2.25	
	Chromium-Molybdenum Irons*			
3.31	1.76	0.73	0.12	0.64
3.37	1.76		0.28	0.64
3.23	1.88		0.47	0.61
3.21	2.06		0.77	0.66
3.23	2.03		0.96	0.68
3.15	1.95		1.42	0.53
3.13	1.81		1.95	0.64
3.16	1.82		2.19	0.55

* S – 0.072%, P – 0.046%, Ni – 0.17%, Cu – 0.07%

dicular to the fractured surface of the bar at the center line of the tensile specimen.

RESULTS AND DISCUSSION

Chemical Analysis

The chemical analyses of the different compositions of gray iron investigated are listed in Table 1. These compositions were generally close to those selected and present a good coverage of the range of molybdenum contents from 0-2.5 per cent. The only serious variations in compositions were:

1) a lower molybdenum content of the highest addition, 2.25 and 2.19 per cent reported in each series when 2.50 per cent was desired,
2) a higher chromium residual of 0.15-0.16 per cent in the first series, and a variation in chromium from 0.53-0.68 per cent in the second,
3) a residual molybdenum content of from 0.05-0.12 per cent for the compositions that were to represent 0 per cent molybdenum,
4) variations in carbon from 3.01-3.37 per cent and in silicon from 1.73-2.06 per cent. While these variations in carbon and silicon undoubtedly had some effect on the strength, they generally occurred gradually as the analysis changed, and none of the compositions was far from a carbon equivalent value of 3.8 per cent.

Soundness and Hardness Survey

The results of the longitudinal sectioning and hardness survey of the bars from each composition indicated that no shrinkage, and little variation in hardness, occurred in the bars with any composition. It was believed that the riser was entirely adequate to avoid any shrinkage, including microporosity, particularly at the low phosphorus level of 0.044-0.047 per cent.[18,19] Even after grinding and etching, the bars showed no shrinkage during visual and microscopic examination. As was anticipated, a slight effect of annealing can be observed, however, in the results of the hardness surveys of the as-cast bars presented in Table 2. The only appreciable change in hardness occurred from the faster cooling rate of the extreme

TABLE 2 – HARDNESS SURVEY OF AS-CAST TEST BARS

Chemical Analysis		Brinell Hardness Number						
Mo	Cr	Ave.	Gate End			Chill End		
0.05	0.16	229	241,	228,	228,	223,	228	
0.22		243	235,	235,	241,	248,	255	
0.50		248	241,	241,	248,	248,	262	
0.76		257	248,	255,	255,	269,	269	
1.00		251	255,	241,	241,	255,	262	
1.54		306	302,	302,	302,	321,	302	
2.02		304	293,	293,	302,	311,	321	
2.25		372	302,	365,	351,	365,	375,	402, 444
0.12	0.64	258	255,	255,	255,	262,	262	
0.28	0.64	277	269,	262,	269,	286,	302	
0.47	0.61	273	255,	255,	269,	286,	302	
0.77	0.66	289	286,	277,	293,	286,	302	
0.96	0.68	300	286,	286,	286,	311,	332	
1.42	0.53	330	332,	302,	311,	332,	375	
1.95	0.64	371	351,	365,	332,	340,	351,	418, 444
2.19	0.55	382	375,	365,	365,	365,	375,	387, 444

TABLE 3 – ANNEALING TREATMENT EFFECT ON HARDNESS

Iron Composition		Average Brinell Hardness Number	
% Cr	% Mo	As-Cast	After Anneal
0.53	1.42	330	268
0.64	1.95	371	279
0.55	2.19	382	271
0.16	2.02	304	261
0.16	2.25	372	263

end of the bars located farthest from the gate. The 5½-in. long tensile specimens were located toward the gate end of the 6 in. long coupon so that this hard end was not within the specimens.

The gray irons with higher molybdenum contents in both series were annealed at 1400 F for 1½ hr before machining the tensile bars. This annealing treatment was conducted to soften the matrix structure so that the machining would be facilitated. It did not appear to decompose the massive carbides but tempered the matrix. The effect of this treatment on the hardness is shown in Table 3.

Short-Time Tensile Tests

The short-time tensile tests indicated that increasing molybdenum content increased the strength of the plain and 0.60 per cent chromium gray irons to a maximum value at 1.4-1.9 per cent molybdenum. These results are shown in Fig. 2 for the iron without a chromium addition, and in Fig. 3 for the iron containing 0.60 per cent chromium. The room temperature strength of the plain irons increased steadily at nearly 2000 psi for each 0.1 per cent molybdenum added up to 1.7 per cent molybdenum. This rate of increase is similar to some irons and slightly greater than others reported.[20] The rate of increase of the room temperature strength of the iron containing chromium was approximately the same up to 0.6 per cent molybdenum additions, but leveled off to only a slight increase in strength for larger additions.

The increase in short-time tensile strength was approximately the same for equivalent molybdenum additions to both irons at 800 and 1000 F testing temperatures. The actual level of strength, particularly

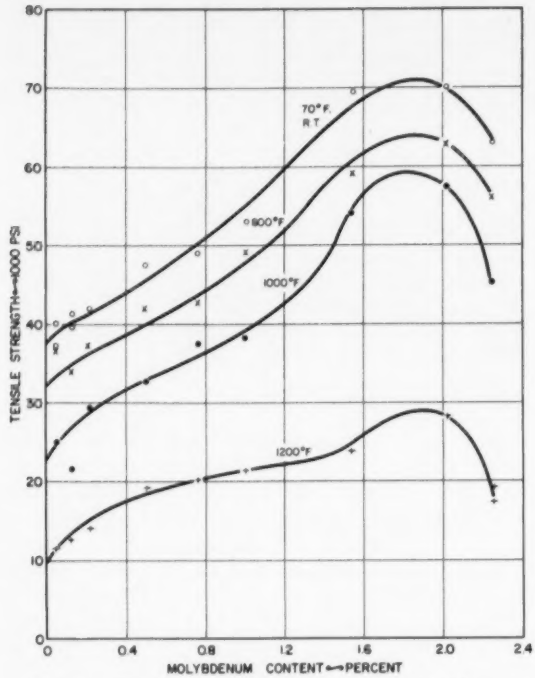


Fig. 2 — Tensile strength as a function of molybdenum content for gray iron at different temperatures.

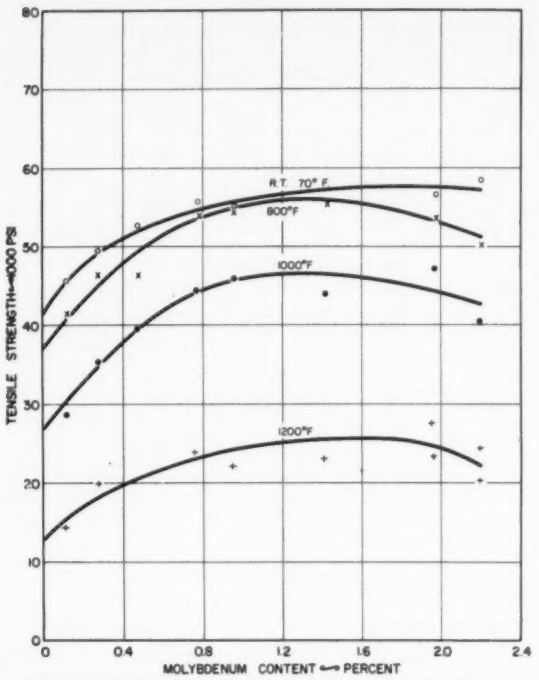


Fig. 3 — Tensile strength as a function of molybdenum content for gray iron with 0.6 per cent chromium addition at different temperatures.

at 1000 F, was somewhat lower than at room temperature. The increased softening effect at higher temperatures is shown by the short-time tensile test results of those specimens fractured at 1200 F. Not only is the strength level considerably lower, but the rate of increase of strength with increasing molybdenum content is less for both irons at 1200 F.

The decrease in strength of both irons at the highest molybdenum contents was believed to be the result of the embrittling effect of considerable quantities of the massive cementite obtained upon solidification of these irons, particularly in the series containing chromium. The presence of this cementite in the microstructure was confirmed by microexamination as discussed in a subsequent section of this paper.

Stress-Rupture Tests

The results of the stress rupture tests conducted on the plain iron with various molybdenum additions are shown in Figs. 4, 5 and 6 for testing temperatures of 800, 1000 and 1200 F, respectively. The stress-rupture curves for the irons containing about 0.60 per cent chromium are illustrated in Figs. 7, 8 and 9 for the testing temperatures of 800, 1000 and 1200 F, respectively. All data are presented on plots of logarithm of initial stress vs. the logarithm of the time to fracture. From six to nine specimens were employed to establish the curve for each composition at each temperature. The data are consistent over the entire time and temperature range. To improve the clarity of the figures, individual points were not plotted; only the straight lines through these points are shown. The time to failure was extended to 100 hr for each curve by extrapolation or interpolation.

The stress-rupture curves of all irons did not show noticeable deviation from linearity within 100 hr at any of the temperatures investigated. Although decomposition of the matrix of some irons was detected at some of the temperatures, it was believed that the change was gradual and, therefore, did not cause a sudden discontinuity in the curve. Others investigating the stress-rupture characteristics at longer times and similar temperatures observed definite changes in slope of some of the curves beyond 100 hr.[7] This was attributed to decomposition of some structure phases.

The decrease in stress-rupture strength with increasing time to fracture was similar for the irons with and without chromium at the different molybdenum contents when tested at 1000 and 1200 F. The comparative performance of the irons at 800 F, however, varied somewhat with the different amounts of molybdenum. When the molybdenum content was between 0.50 and 1.5 per cent, the irons containing chromium did show a slightly smaller decrease in stress with testing times compared to the irons with only a residual chromium content. With a molybdenum addition of about 2.0 per cent, the strength of the iron without chromium decreased at a slower rate at the longer times of stress than the comparable iron with chromium.

This behavior was probably caused by the embrittling effect of the large amount of massive cementite in the high molybdenum iron with a chromium addition. As the testing temperature increased to 1000 and then 1200 F, the stress rupture strength of all irons was reduced considerably and the decrease in strength with increasing time of testing was more marked.

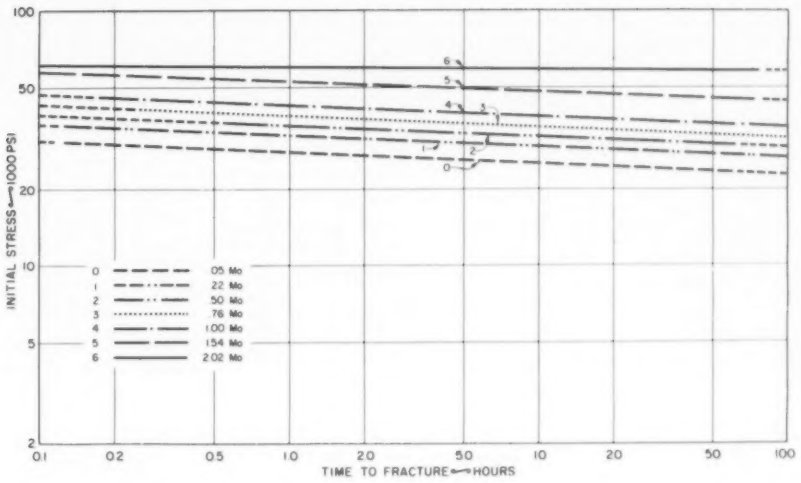


Fig. 4 — Time to fracture at 800 F as a function of the initial applied stress for gray iron with different molybdenum contents.

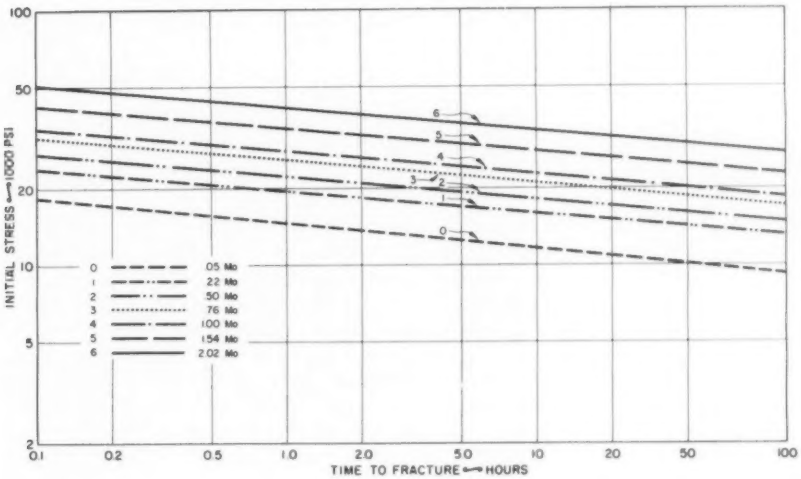


Fig. 5 — Time to fracture at 1000 F as a function of the initial applied stress for gray iron with different molybdenum contents.

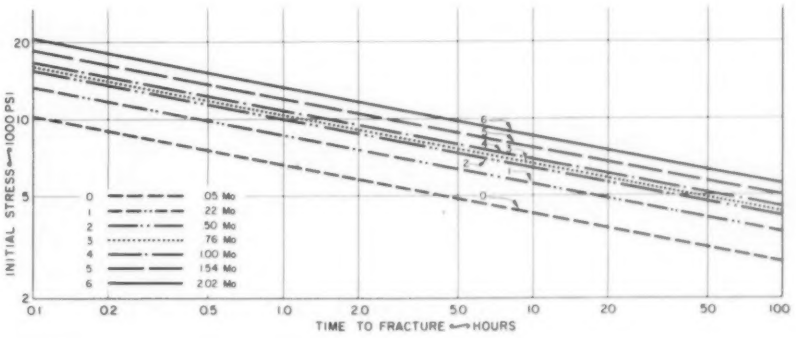


Fig. 6 — Time to fracture at 1200 F as a function of the initial applied stress for gray iron with different molybdenum contents.

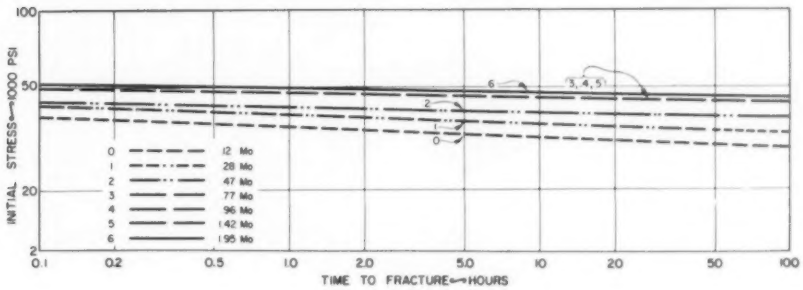


Fig. 7 — Time to fracture at 800 F as a function of the initial applied stress for gray iron with 0.6 per cent chromium and different molybdenum contents.

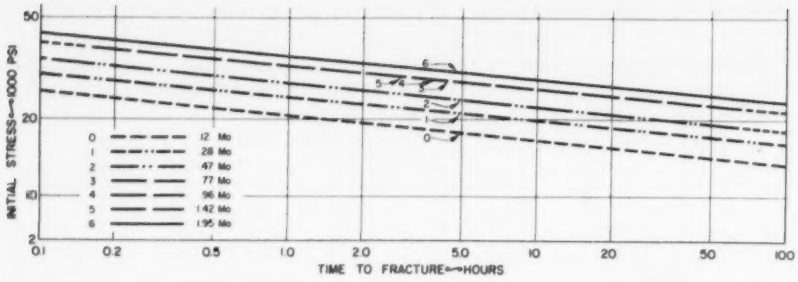


Fig. 8 — Time to fracture at 1000 F as a function of the initial applied stress for gray iron with 0.6 per cent chromium and different molybdenum contents.

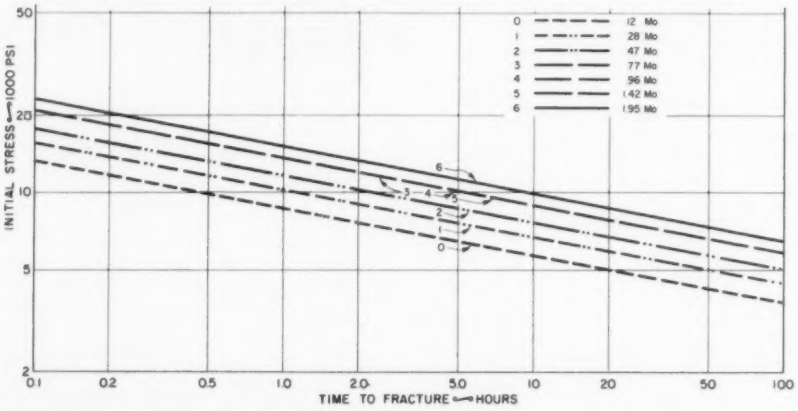


Fig. 9 — Time to fracture at 1200 F as a function of the initial applied stress for gray iron with 0.6 per cent chromium and different molybdenum contents.

The addition of 0.50 per cent molybdenum is apparently more beneficial in improving the stress-rupture properties at all temperatures than a similar amount of chromium. The curve for the iron containing 0.50 per cent molybdenum and 0.16 per cent chromium was consistently higher than the curve for 0.05 per cent molybdenum and 0.64 per cent chromium in Figs. 4-9. The molybdenum was believed to have strengthened the pearlitic matrix, whereas the chromium caused the formation of massive carbides.

While molybdenum consistently improved stress-rupture strength throughout the series of irons in Figs. 4-9, the relative behavior of the higher molybdenum irons with and without chromium additions depended on the testing temperature. At 800 and 1000 F, the irons without chromium and with a 1.54 and 2.02 per cent molybdenum addition exhibited a higher stress level in the stress-rupture curves than the corresponding irons in the series containing chromium. However, at 1200 F, the stabilizing effect of chromium on the matrix was apparent and the stress level of the chromium containing irons was higher for the irons with approximately 1.5 and 2.0 per cent molybdenum than for the comparable molybdenum content irons in the series without a chromium addition.

The effect of molybdenum additions on the initial stress to cause fracture at 100 hr during stress-rupture testing is shown in Fig. 10 for the irons without a chromium addition, and in Fig. 11 for the 0.60 per cent chromium irons. These curves show the beneficial effects of molybdenum and molybdenum with chromium on the stress-rupture properties. Molybdenum additions to the straight molybdenum irons and the series of irons containing chromium result in better higher temperature performance. As the testing temperature increases from 800 to 1000 to 1200 F, the improvement in strength obtained with molybdenum additions decreases steadily. This was believed to be the result of the structural alterations that occurred in the matrix at higher temperatures.

A comparison of Figs. 10 and 11 illustrates the relative effect of these alloys on the 100 hr stress-rupture strength. The series of irons with 0.60 per cent chromium exhibited better stress-rupture strength than the irons with 0.16 per cent chromium from 0 to about 1.5 per cent molybdenum at 800 and 1000 F. At higher

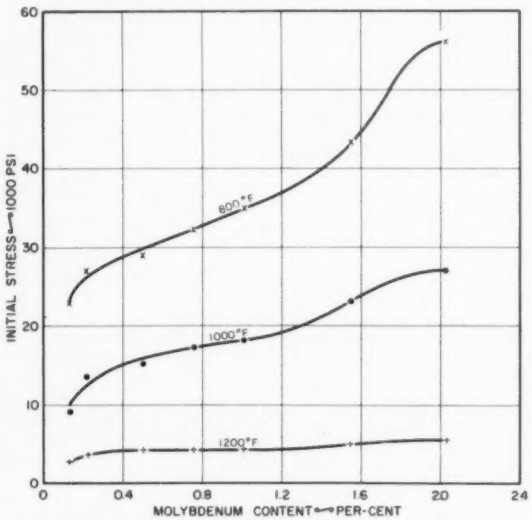


Fig. 10 — Extrapolated and interpolated initial stress to cause fracture at 100 hr as a function of the molybdenum content for gray iron at different temperatures.

molybdenum contents, the irons with residual chromium were superior at these temperatures. At 1200 F, however, the irons with chromium additions were slightly superior to those with residual chromium for all molybdenum contents.

Microstructure

The microstructures of the coupons demonstrate many of the factors that produce the variations in short-time tensile and stress-rupture strength of these irons. The as-cast or annealed microstructures of the plain iron series contained considerably less free or massive cementite than the series containing about 0.60 per cent chromium. The plain base iron with the residual amount of 0.05 per cent molybdenum and 0.16 per cent residual chromium exhibited a microstructure of a pearlitic matrix and graphite flakes, as shown in Fig. 12a.

This structure was not changed appreciably as the molybdenum content was increased to 0.22, 0.50, 0.76 and 1.00 per cent, except for an increase in the fineness of the pearlite. The microstructure obtained with a 1.00 per cent molybdenum content is illustrated in Fig. 12b. When the molybdenum was in-

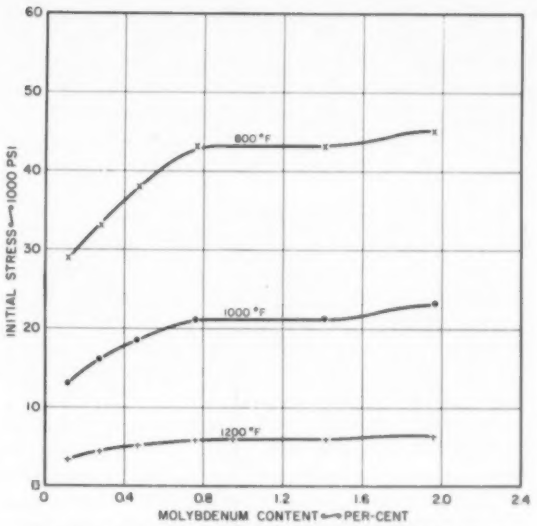
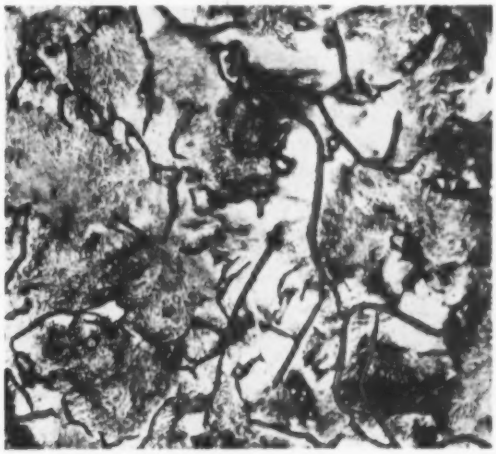


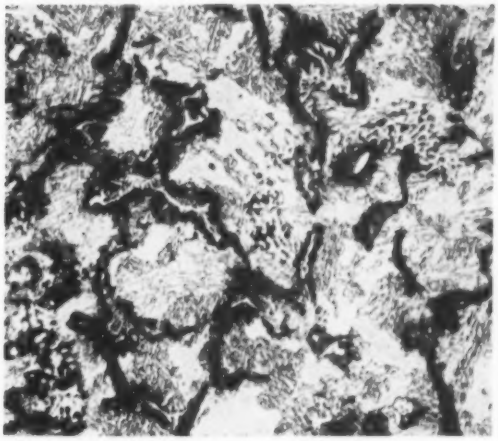
Fig. 11 — Extrapolated and interpolated initial stress to cause fracture at 100 hr as a function of the molybdenum content for gray iron with 0.6 per cent chromium at different temperatures.

a) 0.05 per cent Mo, as-cast



b) 1.00 per cent Mo, as-cast

c) 1.54 per cent Mo, as-cast



d) 2.02 per cent Mo, annealed at 1400 F

Fig. 12 — Microstructures of gray iron at various molybdenum contents with 0.16 per cent chromium, before testing. Picral etch. 250 ×.

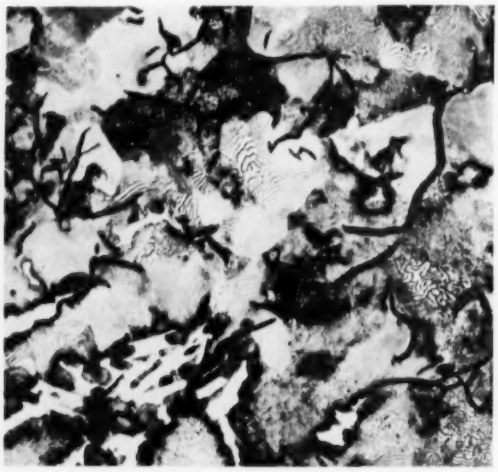
creased to 1.54 per cent, the matrix became a mixture of fine pearlite and bainite (Fig. 12c). A small amount of fine cementite together with graphite flakes occurred in the structure when the molybdenum content was increased to 2.02 per cent. The matrix in this iron was approximately 90 per cent bainite and 10 per cent fine pearlite, as shown in Fig. 12d.

At the highest molybdenum content (2.25 per cent) in this series of irons, the structure contained a slightly larger amount of "skeletal" cementite, graphite flakes and a bainite matrix. This latter iron was not subjected to stress-rupture testing because of the slight increase in molybdenum content from 2.02 - 2.25 per cent, and greater machining difficulties associated with the higher hardness.

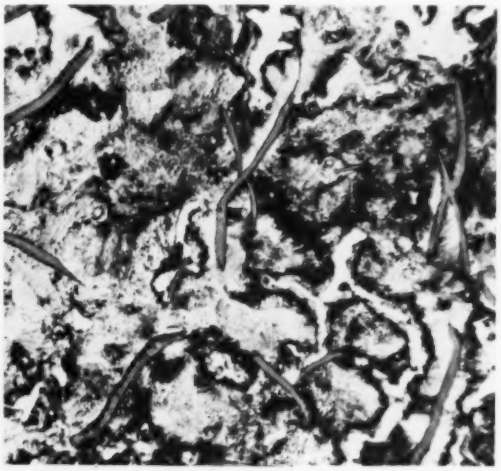
The series of irons with approximately 0.60 per cent chromium contained appreciably more massive cementite and less bainite in the matrix at equivalent molybdenum contents. Prior work[8,10,12] has demonstrated that molybdenum has a greater tendency to change the matrix from pearlite to bainite, and that chromium additions were more prone than molybdenum to produce massive cementite in the structure. In this series, the base iron with 0.12 per cent residual molybdenum and 0.64 per cent chromium contained an appreciable quantity of free cementite together with graphite flakes in a pearlitic matrix, as shown in Fig. 13a.

The size and quantity of the free cementite increased slowly but steadily in this 1.2 in. round section as the molybdenum content was raised to 0.28, 0.47, 0.77 and 0.96 per cent. The microstructure at 0.96 per cent molybdenum is shown in Fig. 13b. In addition to the somewhat larger size and increased amount of massive cementite, the pearlitic matrix was considerably finer than with lower molybdenum percentages. When the molybdenum content was increased to 1.42 per cent in this series the amount of massive cementite increased, but the matrix was still primarily fine pearlite with only small amounts of acicular bainite (Fig. 13c).

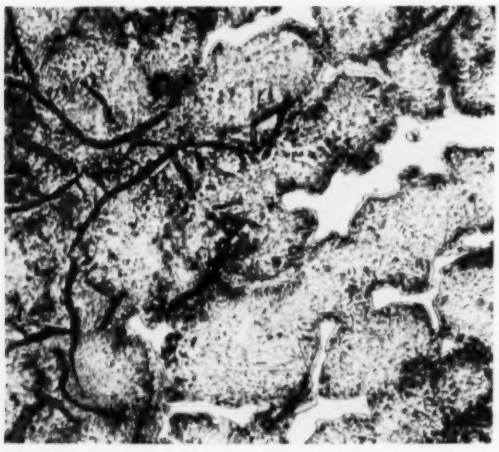
The massive cementite also increased in quantity at 1.95 per cent molybdenum and the matrix became a mixture of 30 per cent fine pearlite and 70 per cent bainite, as illustrated in Fig. 13d. The highest



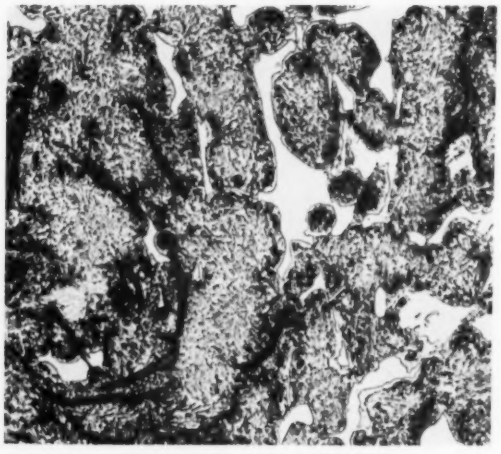
a) 0.12 per cent Mo, as-cast



b) 0.96 per cent Mo, as-cast



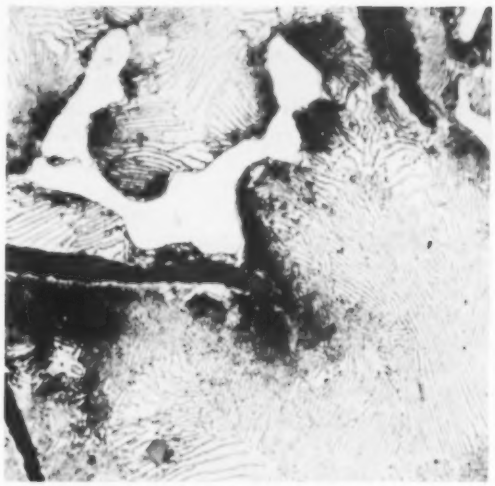
c) 1.42 per cent Mo, annealed at 1400 F



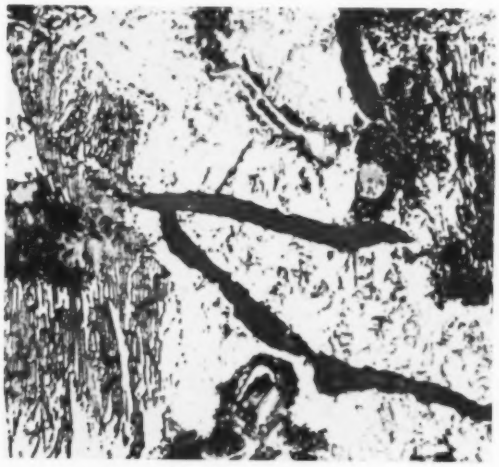
d) 1.95 per cent Mo, annealed at 1400 F

Fig. 13 — Microstructures of gray irons at various molybdenum contents with 0.60 per cent chromium, before testing. Picral etch. 250 ×.

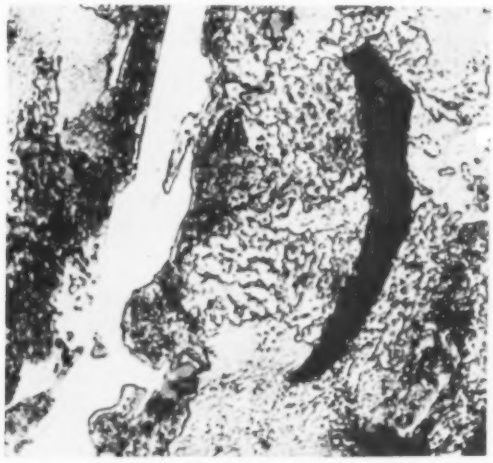
a) 0.05 per cent Mo, 0.16 per cent Cr



b) 0.12 per cent Mo, 0.64 per cent Cr



c) 2.02 per cent Mo, 0.16 per cent Cr



d) 1.95 per cent Mo, 0.64 per cent Cr

Fig. 14 — Microstructures of gray irons of various molybdenum and chromium contents after 100 hr under stress at 1000 F. Picral etch. 1000 ×.

molybdenum iron in this series (2.19 per cent) contained considerable free cementite with graphite flakes in an acicular matrix. Stress-rupture tests were not conducted with this composition because of the high hardness, difficult machining and small increase in molybdenum over the 1.95 per cent molybdenum iron in this series.

Structure Effects on Properties

The influence of structure on short-time tensile strength can be obtained from a concurrent consideration of Figs. 2, 3, 12 and 13. The strength of the series of irons containing chromium is somewhat better than the other base iron at low molybdenum contents for all testing temperatures. As the molybdenum content increases, this difference between the strengths of the irons at equivalent molybdenum contents becomes less. The strength of the two series became equal for the room temperature tests at approximately 1.0 per cent molybdenum, for the 800 and 1000 F tests at 1.4 per cent molybdenum and for the 1200 F tests at 1.6 per cent molybdenum.

At still higher contents than those listed the irons without a chromium addition were generally superior in strength. The strengthening influence of both chromium and molybdenum were apparent at lower molybdenum contents. However, with the larger additions, the embrittling effect of the greater quantities of massive cementite reduced the strength of the series containing chromium. The higher molybdenum irons without chromium additions were strengthened by the greater amounts of bainite in the matrix. The stabilizing effect of chromium on the matrix structure accounted for the better comparative performance at the higher testing temperatures of the series containing this alloy.

The results of microstructural examination of the stress-rupture bars after loading for 100 hr at various temperatures indicate the effect of these conditions on the structures of the different irons. An analysis of these structures and the changes occurring during the tests explain many of the variations in stress-rupture strength shown in Figs. 4-11. Stress-rupture testing at 800 F did not cause any significant changes in the

microstructure of any of the irons containing less than 1.5 per cent molybdenum. A slight amount of decomposition of the bainitic matrices of the higher molybdenum irons was observed. The stress-rupture tests at 1000 F, however, exhibited considerable decomposition of the bainitic matrix in those irons containing bainite.

The pearlitic matrix of the unalloyed and lower alloy irons, however, was not changed significantly by the 100 hr stress-rupture testing at 1000 F. The unaltered pearlitic matrix of the iron containing residual molybdenum and chromium, and the iron with residual molybdenum and 0.64 per cent chromium, are shown in Figs. 14a and b. The agglomeration and spheroidization of the carbides in the bainitic matrices of the irons with 2.02 per cent molybdenum, 0.16 per cent chromium and 1.95 per cent molybdenum, 0.64 per cent chromium after stressing at 100 hr at 1000 F, are apparent in Figs. 14c and d.

The stress-rupture tests to 100 hr at 1200 F indicated considerable decomposition of both the baintic and pearlitic matrices of the series of iron without a chromium addition. The spheroidization of the pearlite is shown in Fig. 15a for the iron with 0.05 per cent molybdenum, 0.16 per cent chromium, and in Fig. 15b for the iron with 1.00 per cent molybdenum, 0.16 per cent chromium. The decomposition of the bainitic matrix for the iron containing 2.02 per cent molybdenum, 0.16 per cent chromium, is readily apparent in Fig. 15c.

The pearlitic matrices of the irons containing chromium were relatively stable during stress-rupture testing 100 hr at 1200 F. Figures 15d and 15e show the stability of microstructure of the irons containing 0.12 per cent molybdenum, 0.64 per cent chromium and 0.96 per cent molybdenum, 0.68 per cent chromium. The higher molybdenum compositions of the chromium irons with bainitic matrices were decomposed to some extent, however, by this 1200 F stress-rupture test for 100 hr, as exhibited by the photomicrograph of the 1.95 per cent molybdenum, 0.64 per cent chromium iron shown in Fig. 15f.

Many features of the stress-rupture results can be explained directly from the influence of the temperature on the microstructures. The more rapid loss of stress-rupture strength with increasing time of testing at the higher temperatures was the result of the decomposition of the matrix. The greater stability of the matrix at 800 F compared with 1000 F is shown by the more rapid increase in initial stress to fracture with increasing molybdenum content at this lower temperature. This effect can be observed for both series of irons in Figs. 10 and 11. The marked decomposition of some of the irons at 1200 F explains the slight improvement in stress at 100 hr testing with increasing molybdenum content, also shown in these figures. The greater resistance of the chromium irons to this decomposition accounted for the superior stress-rupture properties of these irons compared with the straight molybdenum irons at 1200 F.

Comparison with Previous Unreported Data

The information on the effect of molybdenum on the stress-rupture properties obtained previously[9,17] but not published heretofore can be compared with the data in this investigation. This prior work consisted of stress-rupture curves up to 100 hr duration conducted at 800, 1000 and 1200 F on a chromium-containing base iron to which additions of 0, 0.33, 0.60 and 0.81 per cent molybdenum were made. The base iron contained 3.12 per cent carbon, 1.72 per cent silicon and 0.52 per cent chromium. This composition is only slightly lower in carbon equivalent and chromium content than that obtained in this investigation. The irons were cupola melted and sand cast in 2 in. diameter bars.

The results of this previous stress-rupture investigation are reported in Fig. 16 for the three test temperatures. When these data are compared with the stress-rupture curves for the chromium-containing iron obtained in this present work, it is noted that the effect of molybdenum is similar in both series of irons. The stress-rupture curves exhibit the same slope for both investigations at the three temperatures.

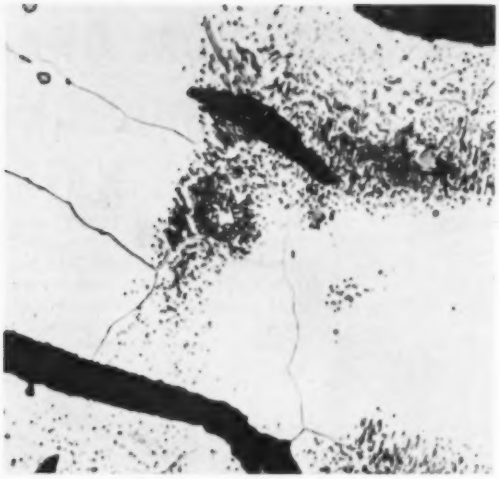
For comparable molybdenum contents, the previous data in references[9,17] are just slightly lower in strength at each fracture time. The effect of molybdenum in increasing the strength at the three temperatures is similar for both types of iron. The stress to cause fracture after 100 hr is about 5000 psi lower at 800 F, 3500 psi lower at 1000 F and only 1000 psi lower at 1200 F for the irons employed in these references.[9,17] The slightly lower results obtained in the earlier work may be attributed to the larger cast section size (2 in. vs. 1.2 in. diameter).

CONCLUSIONS

Molybdenum additions up to approximately 1.5 per cent produce a considerable and consistent improvement in the short-time tensile strength at room temperature, 800, 1000 and 1200 F of a gray iron with a 3.8 per cent carbon equivalent. The strength is only slightly lower at 800 F than at room temperature. Increasing the temperature of testing to 1000 and then to 1200 F results in considerably lower strength levels.

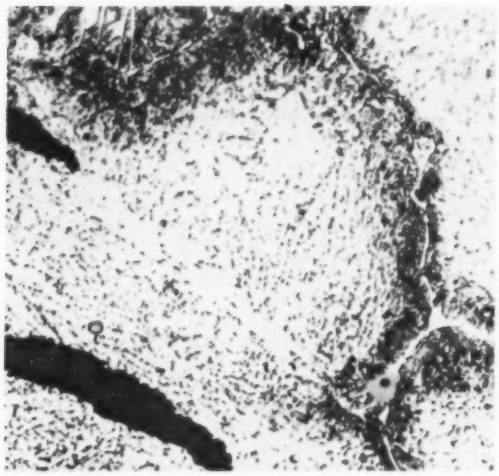
The stress-rupture properties of this gray iron to a fracture time of 100 hr at 800, 1000 and 1200 F are appreciably improved by molybdenum additions up to 2.0 per cent. The incremental increase in strength for each increment of molybdenum decreases as the test temperature is raised. This reduction in the effectiveness of molybdenum additions at higher test temperatures is associated with decomposition of the matrix.

When similar amounts of molybdenum are added to this 3.8 per cent carbon equivalent iron containing approximately 0.60 per cent chromium, the room and elevated temperature properties are further improved for some conditions, but reduced in other cases. The stabilizing influence of chromium on the matrix improves the stress-rupture strength of these irons for all molybdenum contents at 1200 F. At 800 and 1000 F, superior short-time and stress-rupture strengths are obtained with this chromium addition for molybdenum contents up to 1.4 per cent. At higher molybdenum additions, however, the straight molybdenum irons exhibit higher strengths because of the embrittling influence of the massive cementite produced by chromium.



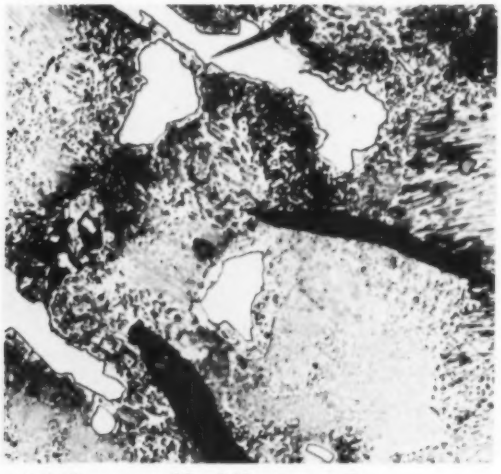
a) 0.05 per cent Mo, 0.16 per cent Cr

b) 1.00 per cent Mo, 0.16 per cent Cr

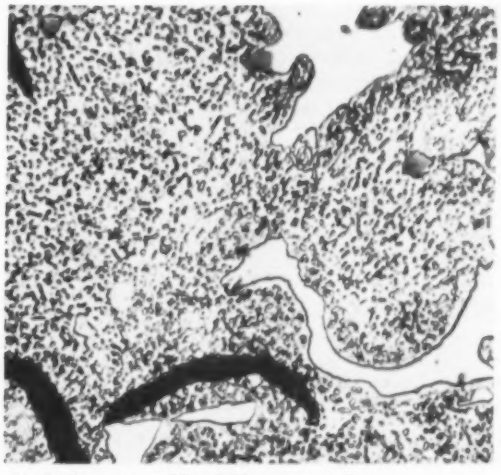


c) 2.02 per cent Mo, 0.16 per cent Cr

d) 0.12 per cent Mo, 0.64 per cent Cr



e) 0.96 per cent Mo, 0.68 per cent Cr



f) 0.95 per cent Mo, 0.64 per cent Cr

Fig. 15 — Microstructures of gray irons of various molybdenum and chromium contents after 100 hr under stress at 1200 F. Picral etch. 1000 ×.

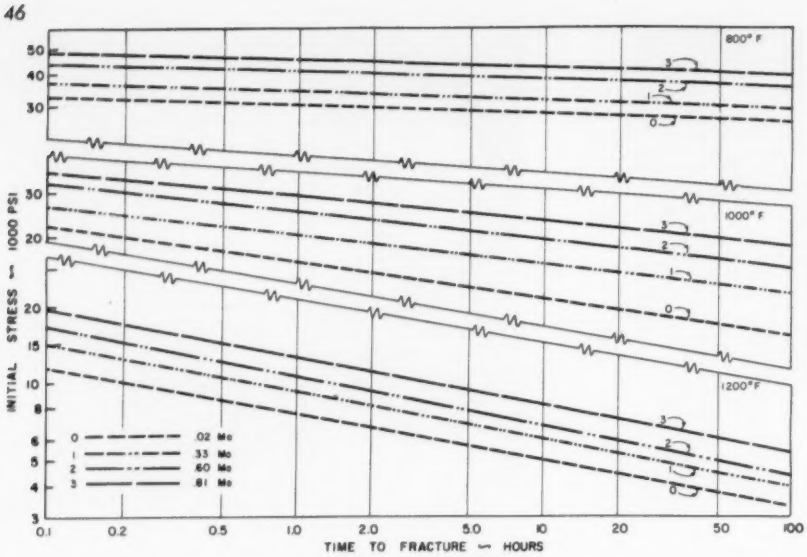


Fig. 16 — Time to fracture at 800 F, 1000 F and 1200 F as a function of the initial applied stress for gray iron with 3.12 per cent carbon, 1.72 per cent silicon, 0.52 per cent chromium and different molybdenum contents. ***(Courtesy Arthur G. McKee Co.)***

The stress-rupture strength decreases uniformly with increasing time of testing to 100 hr for all irons. A more rapid loss in strength with increasing time is evident at the higher testing temperatures. Some of this loss of strength, particularly at the higher temperatures, is attributed to changes in the microstructure. Microscopic examination revealed a slight decomposition of the bainitic matrix at 800 F, further decomposition at 1000 F, and considerable spheroidization of this bainite at 1200 F. The pearlitic matrices showed evidence of decomposition only at 1200 F.

ACKNOWLEDGMENT

The authors are indebted to the Climax Molybdenum Corp., Div. of American Metal Climax, Inc., for their sponsorship of this project at Case Institute of Technology, and to many members of that organization, particularly Messrs. V. A. Crosby and D. V. Doane for their constant assistance and advice. Mr. J. H. Humphrey of that company contributed the work required to develop the annealing treatment and the metallographic examination on the stress-rupture bars after testing. Appreciation is expressed to the Arthur G. McKee Co. for permission to utilize and report the data on the stress-rupture of gray iron contained in references 9 and 17. Superior Foundry provided great assistance in preparing the pattern and molds, and in melting, alloying and casting the test specimens.

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SAND MOVEMENT AND COMPACTION IN GREEN SAND MOLDING

By T. J. Bosworth, R. W. Heine, J. J. Parker, E. H. King and J. S. Schumacher

ABSTRACT

A description of the principles controlling sand movement during squeezing, jolting and contour squeezing, and combinations of these, is given. The compaction process, and development of mechanical properties with increasing density, is also described. Rigid frame design rules for contour squeezing are given, with methods of using the contour frame to achieve molds of high and uniform density and hardness.

INTRODUCTION

When molding is done with green sand, the sand is moved and compacted simultaneously. Forces applied for molding cause the sand to move down into the flask. As it moves, it is compacted, i.e., the bulk density is increased. When the sand has been compacted, and is supported by the flask and pattern, the molding forces are balanced and sand movement ceases. Thus, a study of sand movement in green sand molding must be concerned with compaction and molding forces as well as sand movement.

BULK DENSITY

To describe the limits of compaction or bulk density consider the data in the table. The table shows that the bulk density of a bentonite bonded sand may change from as low as 50 lb/cu ft to as high as 105 lb/cu ft from compaction during the molding process. In a fire-clay bonded sand, the density may vary from about 60 to as high as 115 lb/cu ft during compaction. The higher density level of the latter sand is due to the packing of fire clay in the voids of the sand grain mass.

Even when compacted, the molding sand mass is composed of approximately 60 per cent solids and 40 per cent voids (table).[1,2,3] Regardless of type of bonding clay in the sand, there is a progressive increase in sand bulk density as the amount of work done in compacting the sand increases. The limiting bulk density is achieved when compaction has occurred to the point of sand grain to sand grain contact throughout the mass. This will occur at a density of about 100-115 lb/cu ft. Effort at further compaction then causes sand grain fracture. Application of higher forces will not cause more compaction once the maximum bulk density has been reached.

As compaction of the sand occurs, the mechanical properties of the sand change in the manner shown in Fig. 1. The sand mixture represented in Fig. 1 is composed of 6 per cent western bentonite, 2 per cent D-4 seacoal, 1 per cent carbonized cellulose, balance 85 AFS-4 screen sand. The mixture normally was used at 3.2-3.4 per cent H_2O, although Fig. 1 includes higher moisture contents. As the sand density increases, its green compressive, green shear strength and mold hardness increases. This means that to raise the bulk density from one level to a higher level, sufficient force must be applied to overcome the strength of the sand and cause the increased

TABLE – DENSITIES OF SOME TYPICAL MOLDING SANDS

Material	Bulk Density, lb/cu ft	% Solids*	% Voids**
1. Silica sand (clay free)	100-115	60.4-69.5	39.6-30.5
2. Dry sands plus southern or western bentonite and carbonaceous additives having 9-11% AFS clay, 4-8% total combustible, 60-75 AFS fineness	90-105	54.4-63.5	45.6-36.5
3. Molding sand in No. 2 tempered with water to molding consistency			
a. Riddled	50- 65	30.2-39.2	69.8-60.8
b. Compacted to 70-85 mold hardness	65- 85	39.2-51.3	60.8-48.7
c. Compacted to 90-95 mold hardness	90-105	54.4-63.5	45.6-36.5
4. Fire-clay bonded molding sand; 12-15% AFS clay, 4-8% total combustible, 60-75 fineness; tempered with water			
a. Riddled	60- 75	36.2-45.3	63.8-54.7
b. Compacted to 60-85 mold hardness	75- 95	45.3-57.3	54.7-42.7
c. Compacted to 90-95 mold hardness	105-115	63.5-69.5	36.5-30.5

*True density of solid silica = 165.4 lb/cu ft

$$\text{Per cent solids} = \frac{\text{Bulk Density}}{\text{True Density}} \times 100;$$

$$\text{Example: } \frac{100}{165.4} \times 100 = 60.4$$

**% Voids = 100% – % Solids

T. J. BOSWORTH is Student Asst., University of Wisconsin, Madison; R. W. HEINE is Assoc. Prof., University of Wisconsin, Madison; J. J. PARKER is Secy., SPO, Inc., Cleveland; E. H. KING is Pres., The Hill & Griffith Co., Cincinnati, Ohio; and J. S. SCHUMACHER is Chief Engr., The Hill & Griffith Co., Cincinnati, Ohio.

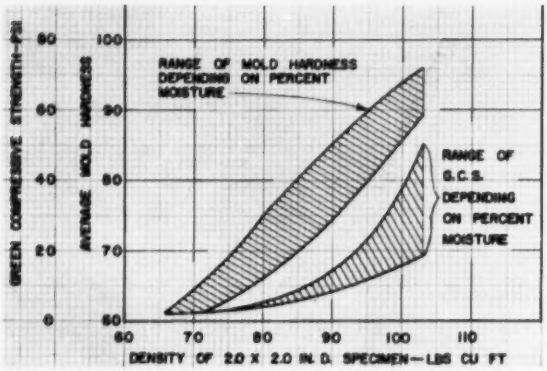
GREEN COMPRESSIVE STRENGTH—PSI
AVERAGE MOLD HARDNESS
RANGE OF MOLD HARDNESS DEPENDING ON PERCENT MOISTURE
RANGE OF G.C.S. DEPENDING ON PERCENT MOISTURE
DENSITY OF 2.0 X 2.0 IN. D. SPECIMEN—LBS CU FT

Fig. 1 — Graph showing how mechanical properties change as compaction of sand occurs, for sand mixture: 6 per cent western bentonite, 2 per cent D-4 seacoal, 1 per cent carbonized cellulose, remainder 85 AFS-4 screen sand.

density. Thus, in green sand molding there are interacting processes at work, as:

1. gross movement of the sand must occur as sand flows above and adjacent to the pattern and is compacted.
2. fitting together or packing of sand grains and expression of the gross voids as the maximum bulk density is approached by compaction.
3. increase of mechanical strength of the sand aggregate as gross movement and packing of the sand occurs.

SAND MOVEMENT

Gross movement of sand during green sand molding was studied by means of a section of a mold, flask and pattern. The section (Fig. 2) consists of a rectangular slab 12 in. high, 9 in. within the flask sides and 1 in. thick. The slab was closed on each face by a metal plate. Distance between pattern and flask is 3 in. on each side. The pattern was made to be either 4 in. high or 6 in. high as desired. Sand was put into the section in a grid pattern of units 2 in. x 1 in. x 1 in. (Fig. 2), in order to observe the movement caused by the molding action. The molding sand mixture was composed of 6 per cent western bentonite, 1 per cent carbonized cellulose, balance 4 screen – 85 AFS sand used at a moisture content of 3.20-3.60 per cent. Seacoal 2 per cent of D-4 grind, was added to a part of the sand to obtain a black color for contrast in the grid of Fig. 2.

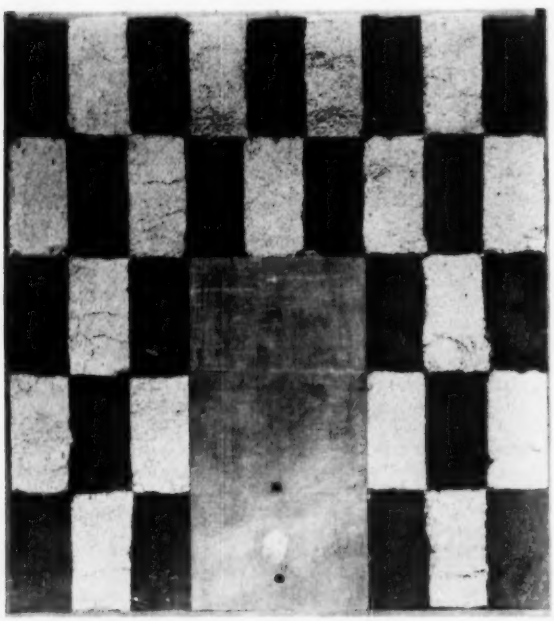

Fig. 2 — Mold, flask and pattern section used to study sand movement. Scale of grid units is 1 in. wide x 2 in. high.

The initial bulk density of the sand was controlled at 50 lb/cu ft by weighing the sand put into the grid. After filling in the grid, the face of the section was covered with a metal plate to confine the sand. Molding effort was then applied in the form of squeezing, jolting or jolting with a follow weight. Sand movement was observed by removing the metal plate and noting deformation of the sand grid. Also, mold hardness measurements were made on the exposed surface and on the surfaces adjacent to the bottom parting, vertical and horizontal walls of the pattern and surfaces in contact with the squeeze plate.

Average final density was also determined by noting the final volume and sand weight. The density at any particular location on the grid can be determined by noting the volume occupied by the original 2 x 1 x 1 in. units. For example, if the height of a unit is decreased from 2.0 in. to 1.0 in., then the density of that unit has doubled, i.e., compacted from 50 to 100 lb/cu ft. Thus, measurement of the grid units shows both sand movement and amount of compaction.

Sand Movement From Squeezing

The gross movement of sand from squeezing alone is illustrated in Fig. 3a. The flask and part of the pattern have been removed in the figure. Mold hardnessess of the grid are shown in Fig. 3b. Figures 3a and 3b reveal a bulged column of sand of maximum mold hardness, 93-98 above the pattern. The height of the grid units above the pattern has been reduced to less than 1 in. from the initial height of 2 in. This means that the density in this location has doubled, i.e., compaction caused bulk density to change from 50 lb/cu ft to about 100 lb/cu ft. Average density of the sand in the mold is only 65 lb/cu ft because of low density near the parting.

At the higher density (100), this sand would have a green compressive strength of more than 50 psi (Fig. 1). Squeezing to this density and strength could be achieved only by applying 50 psi squeeze pressure above the pattern. Note this is pressure above, not adjacent to, the pattern. This is the squeeze pressure required, and it agrees well with earlier work reported.[4] The column of high strength sand over the pattern supports the major portion of the applied squeezing load and transmits it to the pattern.

Figures 3a and 3b also show that a compacted

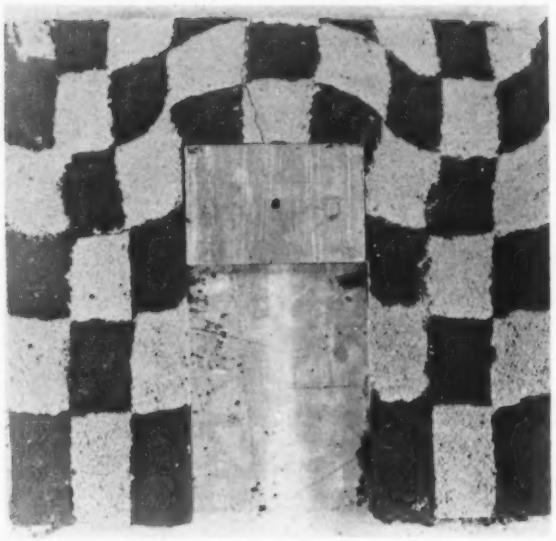

Fig. 3a — Deformation of sand grid caused by squeezing with a flat squeezing plate. Pattern height is 6 in., initial sand height was 12 in., and final sand height is 8 in.

MOLD HARDNESS SURVEY

TOP		91	92	97	98	98	95	93	
	81	86	86	94	94	95	89	89	85
	82	78	87	95	93	98	90	82	87
	68	68	53				63	73	70
	60	61	51				57	60	56
	48	46	45				54	55	60
	36	33	32				48	52	48
	30	25	28				34	40	37
	20	24	8				25	40	29
				TOP OF PATTERN					
PARTING				89	92	95			

Specimen number 53

Flat squeeze X	Contour squeeze		Jolt
Pattern 3 in. x 6 in.			
Initial sand height 12 in.		Density, lb/cu ft 50	
Final sand height 8 in.		Density, lb/cu ft 65	
Remarks: Soft spot at pattern corners. Density nonuniform			

Fig. 3b — Hardness survey of mold section shown in Fig. 3a.

layer of sand builds up in advance of the moving squeeze plate. This compacted layer sends out a compaction wave of partially compacted sand in advance of its own movement. This wave extends downward alongside the pattern, and shows gradually diminishing compaction at greater distances from the parting. The compaction wave does not extend to the pattern plate in this case, because of the resistance to further movement of the squeeze plate offered by the column of sand over the pattern. Consequently, little compaction occurs in the grid units adjacent to the parting, and mold hardness therefore remains low (Fig. 3b).

Rupture of continuity of the sand at pattern corners also may be noted in Fig. 3a. This is the result of bulging of the sand column over the pattern, and attendant side-wise thrust on the sand pushing it away from the corner. Figure 3a also reveals a frictional effect or drag between sand and vertical pattern walls as the sand between pattern and flask moves downward.

Finally, Fig. 3a demonstrates that sand does not flow around corners from above a pattern downward around its sides when squeeze loading is applied. The sand moves by compaction in horizontal l yers and by vertical shear. The combination of horizontal compaction and vertical shear produces the compaction waves, illustrated in Fig. 3a.

Sand Movement in Jolting

The gross movement of sand from jolting alone is illustrated in Fig. 4a and 4b. The pattern and flask have been removed in Fig. 4a. Twenty jolts of 3 in. length were applied to obtain the results shown. Figure 4a shows again the build-up of a column of sand over the pattern. However, this sand column does not reach the high density achieved with squeezing. In this case, density is maximum at the parting and just above the pattern, as shown by hardness measurements and by the grid deformation. A shear plane separates the column of sand over the pattern from the column that moves downward between the pattern and flask walls.

A mold hardness of 82-88 at the parting corresponds to a density of 73-80 lb/cu ft. Average density for this section is 65 lb/cu ft. The average is lower than that at the parting, because density decreases rapidly away from the parting. This is indicated by the grid units at the top of the mold maintaining almost the 2 in. height which they had initially. Again, in jolting, it is seen that virtually no sand moves from above the pattern downward along the sides, i.e., sand does not flow around corners. Discontinuities in compaction of the sand at corners develops because of this lack of fluid flow behavior.

Compaction by jolting occurs at the immovable horizontal surfaces of the pattern and parting. The momentum imparted to the sand during jolting is dissipated in compaction when the sand strikes the immovable surface. Thus, a horizontal compaction wave is set up which produces maximum density at the horizontal surfaces, and decreasing density at increasing distance from the horizontal surfaces. Increasing the number of jolts utilized simply increases the thickness of the compaction wave above the horizontal surfaces. To cause the compaction wave to progress upward along the vertical pattern wall to the top of the pattern would require an impractically large number of jolts.[4,5] Increasing moisture content of the sand greatly increases the number of

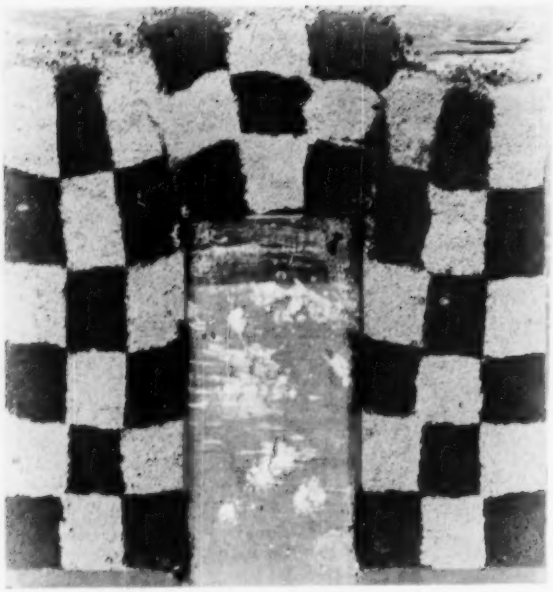

Fig. 4a — Deformation of sand grid caused by jolting the mold section 20 times with a 3.0 in. jolt. Pattern height is 6 in., initial height of sand was 12 in., and final sand height is about 9 in. Pattern and flask have been removed from mold.

MOLD HARDNESS SURVEY

TOP

			26	38	35			
32	33	34	57	58	54	35	38	40
40	45	37	65	68	64	40	36	40
47	48	46				41	47	47
51	52	51	←67			47	53	52
58	59	58	←72			50	54	55
64	60	58	←81		78→	53	56	61
65	65	63	←81		75→	61	61	65
62	63	63	←82		78→	66	64	65

TOP OF PATTERN

PARTING									
	85	88	84	86	82	83	83	82	80

Specimen number 61

Flat squeeze	Contour squeeze	Jolt	20-3.0 in.
Pattern 3 in. x 6 in.			
Initial sand height 12 in.	Density, lb/cu ft 50		
Final sand height 8½-9½ in.	Density, lb/cu ft 65		
Remarks: Shear planes emanating from corners of pattern.			
Density nonuniform			

Fig. 4b — Hardness survey of mold section in Fig. 4a.

jolts required to cause the compaction wave to move up along the pattern.[4,5]

Sand Movement in Squeezing and Jolting

Compaction waves at the top of the mold from squeezing and compaction waves at the parting from jolting could, theoretically, be caused to meet and produce uniform high density molds by combining squeezing and jolting. Figures 5a and 5b show sand movement from jolting, leveling the sand and then squeezing. Maximum compaction occurs in a column of sand over the pattern. Compaction at the parting is caused practically by jolting alone. Minimum compaction and mold hardness occur about half way between the top and bottom, because the two compaction waves have not been brought together. In fact, it is not possible to bring the squeeze compaction wave down to meet the jolt compaction wave, because the sand column over the pattern prevents further downward movement of the flat squeeze plate. Thus, a low density zone will always exist between the two high density zones by this method of molding, unless the flask is shallow; for example, 4 in. deep or less. Because of the low density middle zone, average density was 85 lb/cu ft, although 100 lb/cu ft was approached in the densest layers.

Sand Movement in Contour Squeezing

The limiting effects of columns of sand over the pattern can theoretically be offset by the use of a contoured squeeze plate, rather than by a flat squeeze plate, as suggested in Fig. 6.[4] The design of the squeeze plate is predicted[4] by the formula $U = P/H \times M$.

U = height of the upset or contour block added to the squeeze plate.
P = pattern height.
M = total movement after contact of the contour plate against the sand surface.

The formula is set up graphically in Fig. 6.

As an example of its use, consider the mold section of this study with a pattern height of 6 in., an initial sand height (H) of 12 in., and a movement (M) of 8 in. From the graph in Fig. 6, for $P/H = 0.50$, $M = 8$, $U = 4$ in. The use of such a contoured squeeze plate is shown in Fig. 7a and 7b. In the case shown M was experimentally found to be 8.25 in. where U was 5 in. This design of contour squeeze plate accomplished compaction of sand down to the parting line by squeezing alone. The compaction wave advancing ahead of the contour block has penetrated to the parting to produce high mold hardness both at the parting and vertical side walls. Unfortunately the thin layer of sand between the contour block and pattern is impractical.

In addition, wedging of sand between flask and pattern locks in stresses having a horizontal component that bulges the flask walls. The development of such stresses by diversion of vertically applied load toward horizontal force components is well illustrated in Fig. 8. The wedging effect is analogous to attempting to stuff a large ball into a small hole.[4] This problem is encountered in all uses of contour blocks, air or hydraulic diaphrams, and also of course in using the conventional flat squeeze board.

The problem is one of designing a squeezing method, contour or otherwise, which will prevent

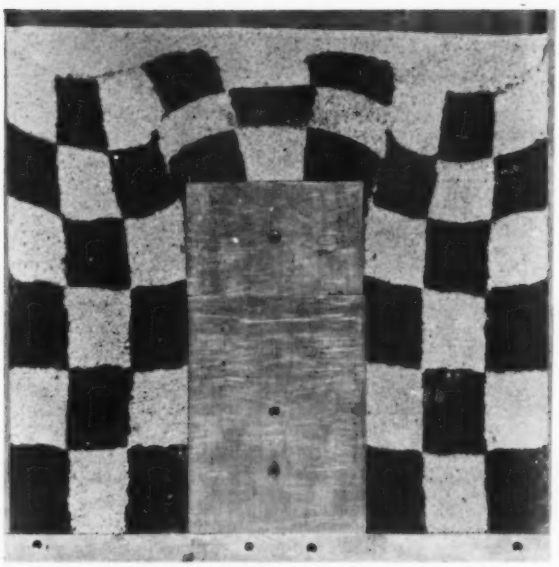

Fig. 5a — Deformation of sand grid caused by jolting 20 times with 3 in. jolt stroke, filling with sand to level and then squeezing with a flat plate.

MOLD HARDNESS SURVEY

TOP	94	95	96	93	94	93	94	95	92
	92	92	91	95	92	94	88	90	94
	91	92	92	95	97	94	92	93	91
	91	92	90	95	93	95	90	91	90
	82	82	81	←77		76→	85	84	86
	77	77	72	←71		73→	75	81	77
	71	71	66	←66		68→	70	71	71
	60	64	60	←78		75→	57	60	63
	63	66	60	←78		77→	63	67	64
	67	59	67	←82		81→	66	67	67
PARTING	82	85	84	93	89	93	83	82	84

TOP OF PATTERN

Specimen number 63

Flat squeeze V	Contour squeeze		Jolt 20-3.0 in.
Pattern 3 in. x 6 in.			
Initial sand height 12 in.		Density, lb/cu ft 50	
Final sand height 8½ in.		Density, lb/cu ft 60-95; 85 ave.	
Remarks: Sand was added to level the surface after jolting, compare with no. 61. Density nonuniform			

Fig. 5b — Hardness survey of mold section shown in Fig. 5a.

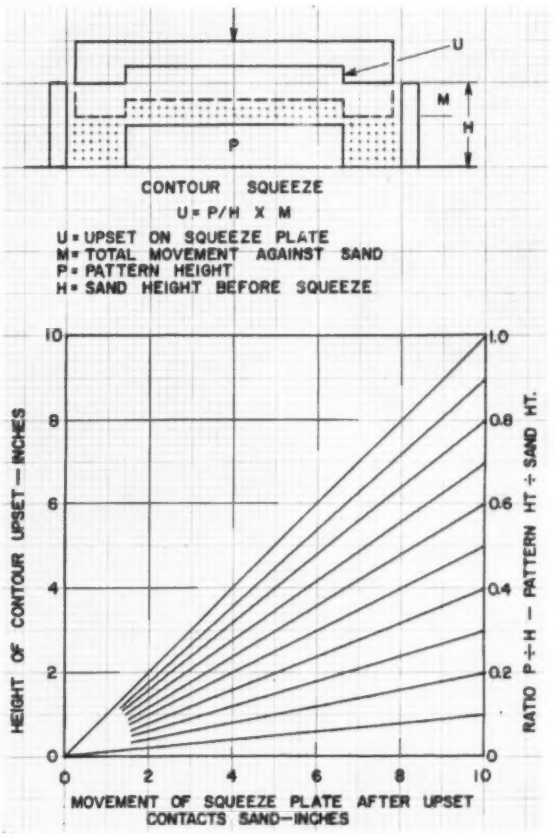

Fig. 6 — Theoretical design of upset on a contour squeeze plate, and graphical means of determining the relation of height of upset to total movement of squeeze plate against the sand.

the building up of columns of sand over the pattern, and also prevent the diversion of forces or wedging effects between pattern and flask.

Many different designs of contour squeezing frames were studied to solve this problem. Finally, contour squeezing was found to be most efficiently performed by means of a contour squeeze frame of the shape shown in Figs. 9a and 9b. Deformation of the grid (Fig. 9a) shows the sand movements caused by this method of contour squeezing. Figure 9b shows the mold hardnesses produced. They are notably high and uniform running 93-96 at the pattern surface. A final density of 95 lb/cu ft or more was achieved. Thus, this method of contour squeezing produces the ultimate in uniformity of hardness and high density.

Sand movement from squeezing by the method shown in Fig. 9 reveals several important phenomenon:

1) Maximum movement and compaction occurs immediately ahead of the tip of the contour block, and extends for a distance of 1½ in. to 2 in. from the tip.
2) When the leading edge of the fully compacted wave ahead of the tip strikes the parting, further movement of the contour frame will be prevented by the sand column between the tip and parting.
3) Horizontal movement of sand toward the pattern is caused by shearing off of compacted sand under the block, and shear movement around the curved tip toward the pattern. Horizontal movement is shown in Fig. 10.

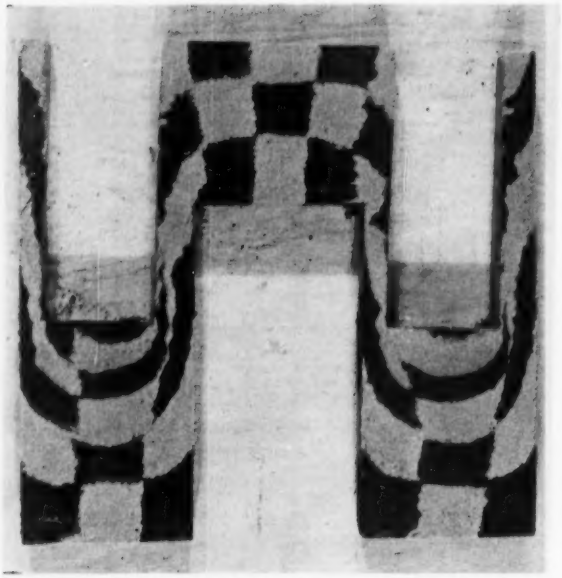

Fig. 7a — Example of use of contour blocks for compacting sand alongside the pattern, and obtaining the hardness down to the parting. Squeezed only. Pattern and flask have been removed.

4) A tear-drop shape compaction wave emanates from the tip, because of the shearing off process, described in 3 above.
5) If a sand column builds up between the contour block tip and the parting before the sand over the pattern is compacted, then the sand over the pattern will not reach maximum hardness and density. The reverse of the situation is also true. This is discussed further in a following section.

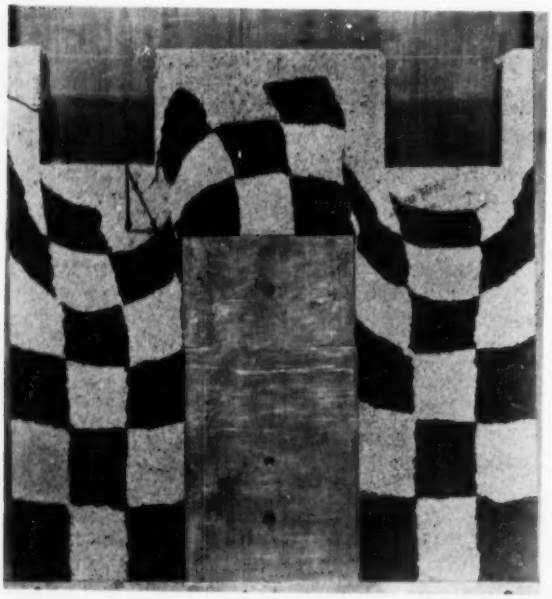

Fig. 8 — Molding section illustrating diversion of vertical squeezing force to horizontal force components. Wedging of the sand causes bulging of flask walls and locked in stresses that make patterns difficult to draw and cause mold cracks.

MOLD HARDNESS SURVEY

TOP	99	99	90	92	94	93	93	99	100
	91			90	92	92	94	94			57
	88			90	90	93	92	92			57
	77			89	92	90	93	91			65
	72			79				81			70
	70			76				76			73
	83	95	91	→97		98→	89	93	92	
	89	93	93	→98		96→	90	92	93	
	87	91	89	→97		95→	89	90	87	
	83	86	87	→97		96→	83	86	83	
				TOP OF PATTERN					
PARTING	96	94	92	98	94	97	84	90	81

Specimen number 57

Flat squeeze	3 in. Jolt	Contour squeeze	V
Pattern 3 in. x 6 in.			
Initial sand height 12 in.		Density, lb/cu ft 50	
Final sand height 8¾ in.		Density, lb/cu ft 80-95	
Remarks: Contour squeeze plate, 2 in. x 5 in. blocks. Density nonuniform, soft spots between contour block and pattern.			

Fig. 7b — Hardness survey of mold section shown in Fig. 7a.

6) Wedging or side-wise thrust against the flask can be eliminated if the contour block is properly designed.

Using this technique of contour squeezing, the goal of achieving high and uniform hardness and density can be achieved with a minimum of molding force and residual stresses. The essential principle of squeezing by this method is utilization of the compaction wave ahead of the contour block, to move high density sand vertically down to the parting and horizontally to the pattern surface. Proper use of the compaction wave eliminates wedging and residual stresses.

Many modifications of pattern and contour frames of this type were studied to further observe sand movement. An increase in pattern height may require addition of a step on the pattern contour block to compensate for the tear-drop compaction movement of the sand (Fig. 10). Figure 10 also shows how horizontal movement of the sand prevents soft, low density areas from developing at corners of the pattern. If the initial density of packing sand into the flask is raised from 50 lb/cu ft to 65-75 lb/cu ft, then the step shown on the contour block in Fig. 10 may not be needed.

Pattern Shape. The effect of inclined and rounded pattern surfaces and pockets was also studied, as shown in Figs. 11, 12, and 13. In each case, the contour squeeze frame produced uniformly high density and hardness, as in the case of Fig. 9. Horizontal sand movement serves to hold the sand against sloping or rounded pattern surfaces, as demonstrated by grid deformation in Figs. 11 and 12. In the case of the

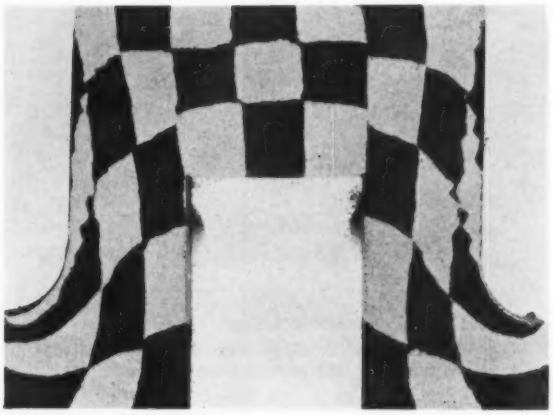

Fig. 9a — Mold section squeezed with specially designed contour frame. Note the tear-drop shape of compaction wave which extends down to the parting, and also causes horizontal movement of sand against the pattern walls.

pocket (Fig. 13) a separate probe must be added to the contour frame to send a compaction wave down into the pocket.

Molding Sand Amount in Flask. One important fact discovered in using the various designs of contour frames concerns the use of the proper amount of molding sand in the flask. When too little sand was used, maximum compaction occurred between the contour block and the parting, but not between the top of the pattern and the squeeze plate. Conversely, when too much sand was used, maximum compaction occurred between the top of the pattern and the squeeze plate, but not between the contour block and the parting. In other words, uniform

MOLD HARDNESS SURVEY

TOP		95	98	97	98	97	98	95	
		94	97	96	98	95	97	94	
		96	94	97	95	96	94	96	
		95	94	94	95	94	93	95	
		94	94				93	92	
		98	95				92	92	
	99	96	95				95	98	98
	99	96	95				96	97	99
					TOP OF PATTERN				
PARTING									

Specimen number 83

Flat squeeze		Contour squeeze ∨	Jolt
Pattern 3 in. x 4 in.			
Initial sand height 10 in.		Density, lb/cu ft 50	
Final sand height 6¾ in.		Density, lb/cu ft 95	
Remarks: Contour block is 5 in. long x 1 in. wide with 1 in. radius on end. Density high and uniform.			

Fig. 9b — Mold hardness survey and contour frame shape of mold section shown in Fig. 9a.

high density and mold hardness was developed only when the proper amount of sand was used in the flask.

The requirement of using the proper amount of sand for squeezing by this method has a fundamental basis. After squeezing, the volume between the contour frame and pattern is fixed. If the volume is fixed, the weight of fully compacted sand in this volume is also fixed. Therefore, only one weight of sand is the correct one to occupy this volume. Ex-

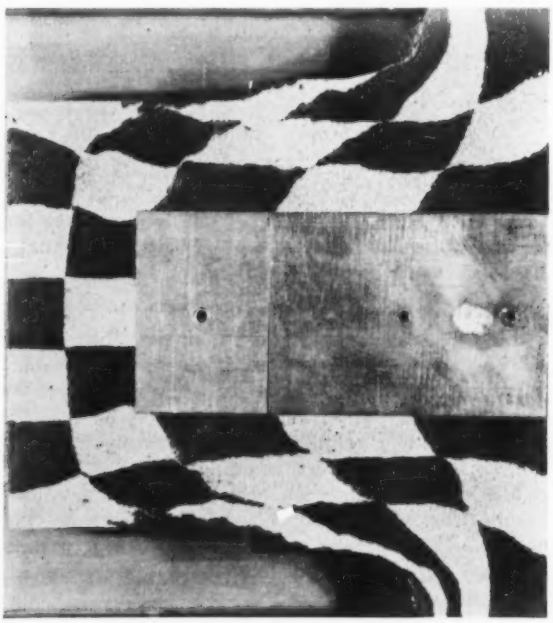

Fig. 10 — Mold section with 6 in. high pattern, and contour plate with step added to avoid low density (and hardness) area at upper corner of pattern.

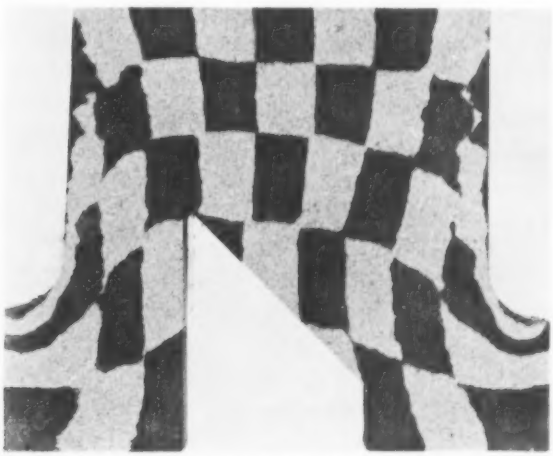

Fig. 11 — Sand movement pattern developed by squeezing against an unlined surface with the contour frame.

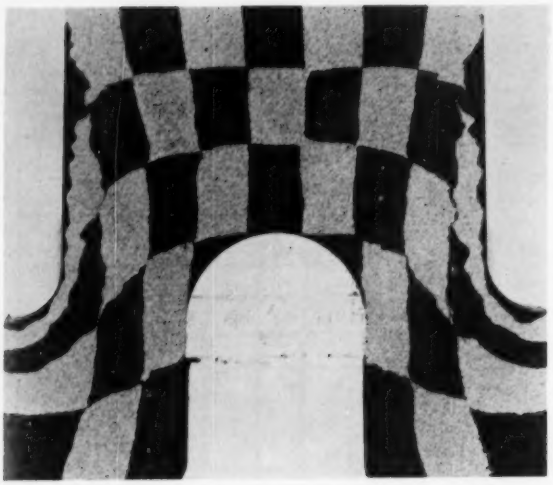

Fig. 12 — Sand movement pattern developed by squeezing against a curved surface with the contour frame.

perimentally, it was found, both in the mold section and in actual molding, that by weighing the amount of sand going into the mold the proper volume after squeezing was assured. Actually, this requires sand on the basis of 100 lb sand to occupy 1 cu ft, in the case of bentonite bonded sand.

Design Rules for Contour Squeezing

Further studies of squeezing molds with the contour frame resulted in a set of rules for designing the squeezing frame. They are:

1) The probe (contour block) height should be equal to 1 to 1.20 times the pattern height.

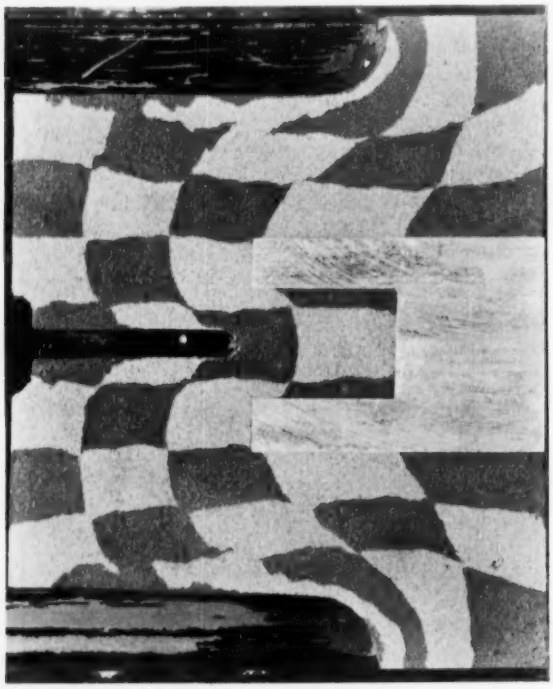

Fig. 13 — Squeezing into a pocket with a probe.

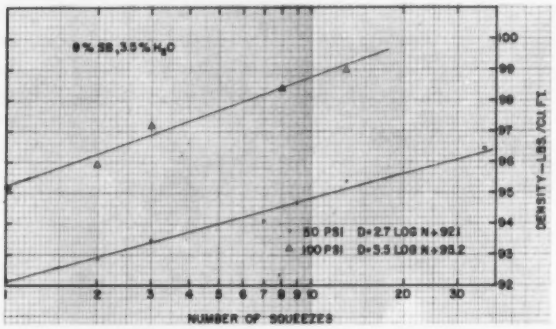

Fig. 14 — Effect of number of squeezes on density of a sand using two different squeeze pressures.

2) Thickness of the probe should be ¼ to ⅓ of the distance between the pattern and the flask.
3) The tip of the probe is a quarter circle of radius equal to probe thickness. It may also consist of 4 inclined planes of 22.5 degrees.
4) The probe sides should be vertical or have not more than one degree taper.
5) A step addition may be made to the inside of the probe, if the pattern is more than 4 in. high. The step addition is ¼ to ⅓ the width of the probe, and 2½ to 3 in. from the tip of the probe. This step addition is not needed unless soft spots are encountered on vertical walls, or initial density of sand packed in the flask is low.
6) The amount of sand put into the flask must be controlled by weighing. The sand weight should correspond to the volume of sand required between the contour frame and the pattern after compaction to a density of 95-100 lb/cu ft. An alternative to weighing the sand is to have contour blocks which move independently of the flat squeeze plate.
7) Additional probes are required to pack sand into pockets (Fig. 13). These probes are designed to be long enough to reach to within 1½ to 2.0 in. of the bottom of the pocket after squeezing. Further, these probes should have a thickness (diameter) equal to ¼ to ⅓ of the width (diameter) of the pocket.

Using these rules, the authors have designed contour frames for squeezing a number of different pattern and flask combinations in foundries.

Contour Frame and Jolting

The contour frame designed as described above can be used for several different techniques of molding. After the flask has been loaded with the proper weight of sand, conventional jolting may be applied. Jolting can then be followed by squeezing with the contour frame to complete molding.

The contour frame can also be used as a follow-weight in jolting. After filling the flask with the proper weight of sand, the frame is placed in position and jolting performed. When completely jolted, the frame will settle into the same position it would occupy from squeezing. The follow-weight must weigh about 0.75-1.0 lb per sq in. of flask area, to have sufficient ramming power if the frame is used as a

follow-weight. However, the same uniform high density and mold hardness of sand will be obtained as by squeezing.

COMPACTION

The preceding paragraphs have dealt with gross movement of sand during squeezing or jolting. Compaction, or increase in bulk density, occurs as the sand is caused to move by the forces of squeezing or jolting. This occurs in several stages:

a) Expression of gross voids from loosely packed sand.
b) Buildup of horizontal layers of higher density sand under a moving squeeze plate, or on the parting from momentum of the sand in jolting. High density layers of sand are also built up in waves on horizontal and vertical surfaces of contour squeeze frames.
c) Eliminations of low density areas and complete expression of gross voids by the impact of high density layers against each other.
d) Fitting together of agglomerates and particles as maximum bulk density is approached from the effects of items a, b and c, above.

The above changes are naturally overlapping in various parts of the mold. However, as maximum density is approached there is obviously no longer any room in the mass for gross voids or low density areas. In other words, maximum density implies uniform density and uniform packing of the sand. This is a primary advantage of molding sands rammed to high density; they cannot be nonuniform in density or properties.

Another consequence of the above modes of compaction, is the manner in which mechanical properties of the sand change. Refering again to Fig. 1, it is seen that green compressive strength and mold hardness change slowly as density increases from 60 to 80 lb/cu ft. However, as density increases from 80 lb/cu ft upward, these mechanical properties shoot up dramatically, as shown in Fig. 1. This is also true in connection with mold wall movement and consequent dimensional accuracy of castings.[4] Much greater dimensional accuracy is obtained when mold hardness exceeds 92 and density exceeds 95 lb/cu ft,[4] for bentonite bonded sands.

Considering a number of sands, it has been found that the bulk density which is at least 94-95 per cent of the maximum obtainable is desired in order to obtain a practical combination of uniformity of density, high mold strength and hardness and dimensional accuracy of castings. For bentonite bonded sands this will amount to about 90-98 lb/cu ft depending on additives, and for fire-clay bonded sands this will amount to about 108-115 lb/cu ft again depending on additives.

As pointed out in the preceding paragraph, mechanical strength of the sand increases greatly as compaction causes maximum density to be reached (Fig. 1). If simple compression only were acting when a mold is squeezed, Fig. 1 shows that squeeze pressure of 40-50 psi would be adequate to obtain full compaction. However, sand columns build up over the pattern and prevent uniform application of the squeeze pressure (Fig. 2). No mere increase in squeeze pressure will compensate for the resistance offered by such sand columns.

Pressures as high as 40,000 psi have been used experimentally, with fragmentation of the sand grains in the column as the only result. Instead, the squeeze pressure must be properly applied so that the full benefit of applied forces can be obtained. The contour squeeze frame described accomplishes this by utilizing and placing compaction waves in their proper relation, and preventing sand columns from building up until maximum compaction has occurred.

Green shear strength, as well as green compression strength, is involved in sand movement and compaction. Green shear strength of a practical maximum of about 8.0 psi is observed in bentonite bonded sands. Thus, 8 psi of load would be the maximum required to cause shearing of a 1.0 in. sand column for each in. of height. For example, in a 12.0 in. deep flask, 96 psi load would be required to cause the shearing in final compaction. According to experimental measurements using molds and mold sections, molds of 12-20 in. depth can be squeezed with pressure of 60-80 psi ro reach full compaction, if the forces are properly applied as with the contour frame. Practically, a limit of about 150 psi is desirable to accommodate unusual depth and patterns.

Another evidence that moderate squeeze pressure can achieve high density is offered in the results of repetitive squeezing. Repetitive squeezing in a low squeeze pressure can achieve the same density achieved by a single squeeze at higher pressure, as illustrated in Fig. 14. One squeeze at 100 psi produces 95.2 lb/cu ft density, while 14 squeezes at 50 psi will produce the same density. Repetitive squeezing permits relief of locked-in stress, and further compaction after reapplication of load. A single high pressure squeeze with a flat plate is partially diverted to side walls. The contour squeeze frame prevents this by permitting proper distribution of the squeezing force.

ACKNOWLEDGMENTS

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SAMPLE FOR RAPID MEASUREMENT OF GAS IN ALUMINUM

By H. V. Sulinski and S. Lipson

ABSTRACT

A rapid quantitative test for gas in aluminum has been developed. The gas content is determined by a single weighing of a 20-cc sample solidified at approximately 0.1 atmospheric pressure. A resin bonded shell mold and knock-off riser system of special design permits close control of as-cast specimen volume. Based on the reproducibility data, empirical values for gas content can be obtained with a standard deviation (σ) of 0.002 cc/100 gr.

The empirical gas content values determined by the test probably approximate the true gas content of the sample. Sampling temperatures between 1250 and 1450 F have no apparent effect on the test results. The constant volume sample reduced pressure solidification test can provide a quantitative measure of the gas contained in a melt within 4½ min from sampling, and with equipment sufficiently rugged to permit use directly on the production foundry floor.

INTRODUCTION

A great deal of effort has been directed, during the past few years, toward the development of techniques for the production of premium quality aluminum alloy castings. These castings are for applications where high strength and reliability are the primary requisites. These applications are for critically stressed castings such as are to be found in missile components, lightweight armored vehicles and in aluminum alloy armor. The techniques that have been developed include close control of the gas dissolved in the molten aluminum.

Gas contained in the melt is removed by chlorine or nitrogen degassing. The termination point of the degassing treatment can only be determined accurately if one has an accurate measuring procedure for the gas content of the melt. Fixed degassing times are not desirable because:

a) There is no assurance that all the gas has been removed if unusual conditions, such as humid atmospheres or poor ingot quality, are encountered.
b) Excess chlorination must be avoided to prevent depletion of certain alloying elements as magnesium in 356 alloy and removal of grain refining additions from the melt.

The reduced pressure solidification test has become an integral part of any process designed to produce high performance castings. The test is performed by permitting a sample of metal taken from the melt to solidify at reduced pressure. Gas precipitated from the melt occupies a volume which is related to the solidification pressure in accordance with Boyle's Law. If 0.1 of an atmosphere is used, the volume occupied by the gas is magnified by a factor of 10. The sample is usually evaluated on a qualitative basis. For these premium quality castings, however, qualitative estimates of the volume of gas in the melt are inadequate.

Either sectioning of the sample to detect evidence of gas holes or density measurements are employed to insure that the degassing operation has been taken to completion. Both of these methods for evaluation of the test specimen leave something to be desired. The sectioning method requires careful polishing of the sample to avoid smearing over the gas holes, and the density measurement is equally time consuming and cumbersome.

Attempts have been made to devise specially adapted balances to reduce the time required for density measurement.[1,2] One such attempt was made at this laboratory through the development of special apparatus designed to measure density by means of liquid displacements.[1] While this method was rapid, its accuracy was limited to $\pm$ 0.02 gr/cc, and the need for this special apparatus impeded its acceptance for production foundry use. In a further effort to improve the sensitivity and ease of specimen evaluation, the concept of a constant volume sample was evolved.

In consideration of the great strides made during the past few years in perfecting precision casting processes, it was postulated that a sample mold could be developed where the volume of the sample could be reproduced within narrow limits. A simple weighing would then suffice for a positive evaluation of the sample. After reviewing the processes which could be used, the shell mold process was selected for casting the constant volume samples. A program was then established for development of a constant volume sample for the reduced pressure solidification test.

METHODS, MATERIALS AND APPARATUS

Selection of Mold Type

The shell mold was selected as the medium into which the constant volume reduced pressure solidification samples were to be cast. This selection was made for the following reasons:

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1) High permeability – mold gases are readily evolved.
2) Non-hydroscopic nature – permits storage under typical foundry conditions.
3) Ease of manufacture – fulfills requirements of expendable mold.
4) Low thermal conductivity – eliminates need for preheating.
5) Dimensional accuracy – close mold volume control.

Sample Cup Design

The design of the specimen must be such as to insure that adequate feeding is provided under all conditions of test. This is because the problem of feeding the sample becomes most difficult and significant when the gas sample contains little or no gas. An improperly risered specimen under these conditions will develop shrinkage cavities, which on the basis of the test parameters will be indistinguishable from voids resulting from gas. A truncated cone design was adopted because of its favorable geometry with respect to feeding.

The size of the specimen was selected on the basis of the needs of the test. A large specimen would provide the maximum in sensitivity; however, the solidification time would become excessive and defeat the purpose of the test which is to provide a rapid measure of the gas contained in the melt. A compromise size of 20 cc was finally selected. This requires a solidification time of slightly better than 2 min, which on the basis of previous work, was considered to be optimum. By controlling the specimen volume at exactly 20 cc the conversion from weight to density could be readily performed by a simple mental computation. For this work, however, time was not taken to adjust the specimen volume to exactly fulfill this requirement.

Figure 1 is a detailed cross-sectional drawing of the sample cup mold. The choke-type gate serves a threefold function. In addition to its function as a channel through which the metal flows into the test specimen segment of the mold, it provides a hot spot for maintaining a fluid channel for feeding and a notch so that the riser segment of the casting can be readily separated from the constant volume specimen. The methods used for production of this mold will be discussed in the following section.

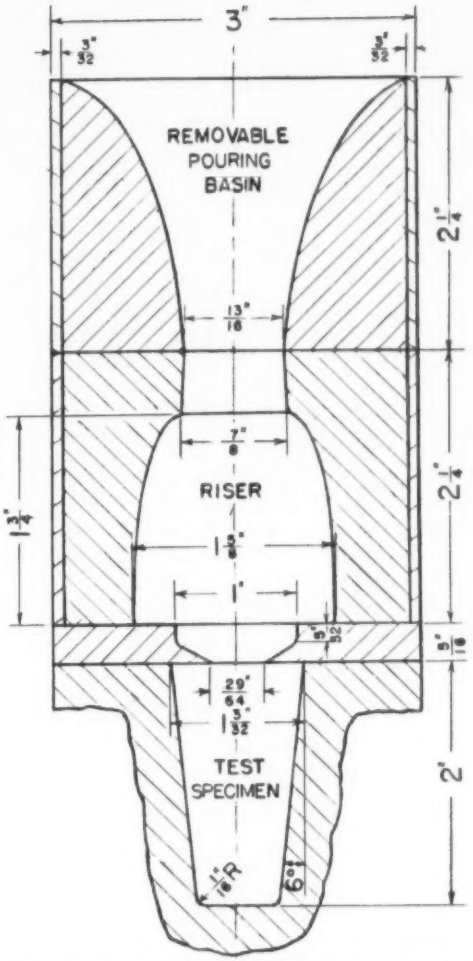


Fig. 1 — Cross-sectional drawing of the constant volume mold. The choke-type gate serves a threefold function: 1) a channel through which the metal flows into the test specimen, 2) provides a hot spot for maintaining a fluid channel for feeding, and 3) provides a notch so the riser segment can be readily separated from the specimen.

Sample Cup Production

Test Specimen Segment. The test specimen portion of the constant volume mold was made by the shell-molding process utilizing a semi-automatic shell-molding machine. The specimen molds were prepared from a shell-molding mixture consisting of 94.8 per cent silica sand (AFS Fineness 120-150), 5 per cent resin and 0.2 per cent kerosene. The process variables were controlled to produce a shell approximately ⅜-in. thick.

Figure 2 is a photograph of the pattern plate used to make the test specimen molds. The plate was designed so that 12 test specimen molds could be made simultaneously by simply cutting the shell (12 in. x 18 in.) up into twenty-four 3-in. squares (12 copes

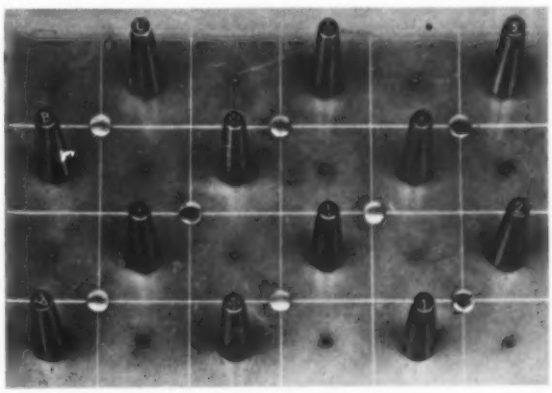


Fig. 2 — Shell mold pattern plate for making the test specimen portion of the constant volume mold. Twelve test specimen molds can be made simultaneously by cutting the shell into twenty-four 3 in. squares.

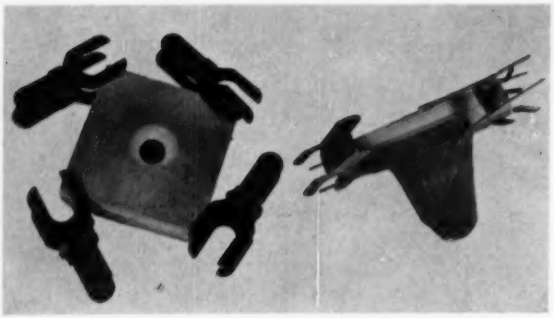


Fig. 3 — Constant volume shell mold showing method of assembly. The shell halves are clamped together by four pinch clamps.

and 12 drags). The pattern plate was an aluminum base material and the specimen inserts were cast iron pieces fastened to the plate by means of machine screws. These inserts produced a specimen cavity of approximately 20 cc. No attempt was made to adjust the individual specimen to produce specimen cavities of identical volume. Each of the inserts was appropriately identified, and the resulting specimen shell and casting also carried the insert identification.

The actual volume of each of the 12 specimen castings was calculated so that the test specimen weight could be related to its actual volume. The specimen shells were grouped so that for each series of tests all the shells were produced from a single insert. Before the shell halves were assembled, the backs of the copes were ground flat (approximately $\frac{5}{16}$-in. thick) on a belt sander and gated, as shown in Fig. 1, using a $\frac{29}{64}$- and 1-in. diameter drill. If the copes were to be made in a blowing machine, the grinding and drilling operations would be unnecessary. Two assembled test specimen molds are shown in Fig. 3. The shell halves were clamped together by four pinch clamps.

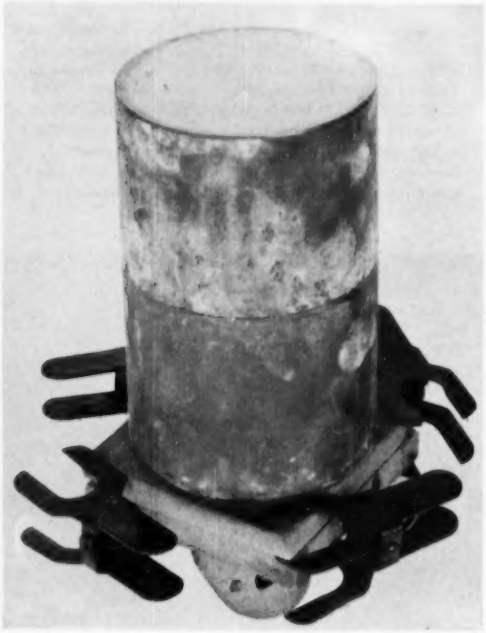


Fig. 4 — Completely assembled constant volume mold with plaster riser and pouring basin in place. The riser and pouring basin are encased in a 3 in. diameter hollow steel cylinder.

TABLE 1 – CHEMICAL COMPOSITION OF 356 ALLOY

Element	Wt. %
Silicon	6.5-7.5
Magnesium	0.2-0.4
Iron	0.6 Max.
Copper	0.2 Max.
Manganese	0.35 Max.
Zinc	0.3 Max.
Titanium	0.25 Max.
Other Elements, each	0.05 Max.
Other Elements, total	0.15 Max.
Aluminum	Remainder

Riser and Pouring Basin Segments. The riser and removable pouring basin were made out of a non-ferrous investment (70 per cent silica – 30 per cent gypsum) material consisting of 1¼ lb investment and 300 cc water. After the plaster molds had set (15 - 20 min) and the patterns had been removed, the molds were dehydrated and calcined in an oven for 16 hr at 600 F. A completely assembled constant volume mold is shown in Fig. 4. The plaster molded riser and pouring basin were encased in a 3 in. diameter hollow steel cylinder, $\frac{3}{32}$-in. thick and 2¼-in. in height. Encasing them in a steel cylinder enables them to be reused many times.

Plaster molds, when allowed to stand at room temperature for a period of time, will absorb some moisture. Thus, before actually using the plaster molds they were given an additional dehydration treatment. This treatment consisted of pouring molten metal into them twice and allowing the heat to soak in for a short period of time.

Melting Equipment, Material, and Procedures

Heats were melted in a 3000-cycle lift-coil induction furnace, and a gas-fired furnace using clay-graphite crucibles. The induction melts weighed approximately 25 lb, and the gas-fired melts approximately 15 lb. Commercial 356 alloy ingot melting stock was used throughout this investigation. The Federal Specification (QQ-A-60lb) of this alloy is given in Table 1.

Degassing treatments, where employed, were accomplished by bubbling chlorine gas through the melt for 10 min with the melt temperature at approximately 1300 F. Gaseous heats were obtained by poling the melt for 2 min with green wood.

Approximately 100 - 120 grams of metal were poured into each constant volume mold. The molds were all poured at 1300 ± 5 F. Temperature measurements were made using a portable potentiometer and a chromel-alumel thermocouple. The thermocouple was encased in a stainless steel tube.

Reduced Pressure Solidification Test Method and Apparatus

The reduced pressure solidification test is a method extensively used in experimental work and in industry for estimating the volume of gas in molten aluminum. The test is performed by permitting a sample

of metal taken from a melt to solidify at reduced pressure. When a sample of a melt is solidified under reduced pressure, the volume of the cavities formed in the metal by the entrapped gas will be inversely related to the solidification pressure (Boyle's Law). The gas content of the sample may be qualitatively evaluated by examining the appearance of the free surface of the specimen. A convex surface is indicative of high gas content, and a concave surface is indicative of freedom from gas. Quantitative information about the gas content can be obtained by measurement of the void volume present in the specimen.

A photograph of the reduced pressure tester used in this work is shown in Fig. 5. The unit conforms basically with the reduced pressure apparatus developed by Baker.[3] Essentially, the apparatus consists of a mechanical vacuum pump, mercury monometer, needle valve,* main vacuum control valve, vacuum release valve, rubber hose lead, pyrex glass vacuum chamber partly filled with brass shot and a rubber O-ring gasket. The mold was partially imbedded (up to its flange) in the shot to seat the mold and to provide a heat sink.

In an actual experiment run, the testing procedure was as follows: After a sample of metal taken from a melt was poured into the constant volume mold, the pouring basin was immediately removed and the vacuum chamber was closed. The main vacuum valve was then opened, and a pressure of 80 mm of mercury on the manometer was obtained by properly adjusting the needle valve. Finally, after 4 min the test mold was removed from the vacuum chamber after closing the main valve and opening the vacuum release valve.

RESULTS AND DISCUSSION

Gate

An investigation was made to determine the optimum size of the gate. To make this study, duplicate constant volume samples were cast using gates varying in diameter from 0.250 - 0.625 in. These samples were cast from an induction furnace heat of metal in the as-melted condition. All of the samples were solidified at atmospheric pressure.

After the riser segment of the casting was knocked off, the center portion of the top surface of each specimen was carefully ground flat to avoid introducing an error due to an irregular fracture. The samples thus obtained were then weighed on an analytical balance.

The results of this work are shown in Fig. 6. From the results obtained it can be seen that a minimum gate diameter of about 0.300 in. is necessary to insure satisfactory feeding of the constant volume segment of the casting. A gate diameter of 0.453 ($^{29}/_{64}$) in. was used for this work. Complete feeding of the casting is mandatory. An improperly fed constant volume sample will develop shrinkage cavities which, on the basis of the test parameters, will be indistinguishable from voids resulting from gas.

Experience has shown that the angle formed between the gate and specimen by virtue of drilling the $^{29}/_{64}$ and 1 in. diameter holes must be sharp and unrounded. Generally, a rounded angle will result in an irregular type fracture.

*The needle valve produced a controlled rate of leak in the system and was effective in control of solidification pressure.

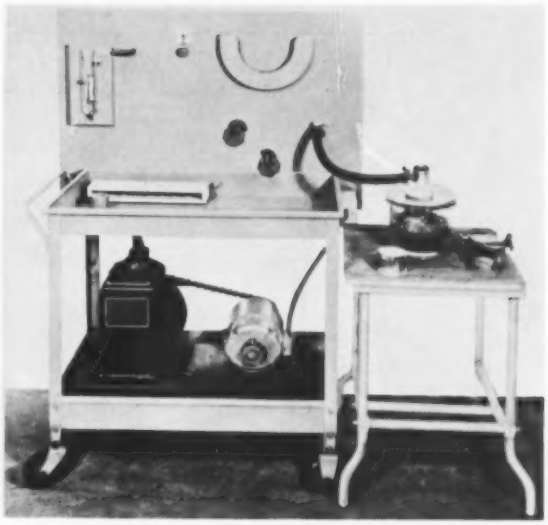


Fig. 5 — Reduced pressure test apparatus used in this work. The unit conforms basically with the apparatus developed by Baker.[3]

Reproducibility Tests

To determine how accurately the volume of the sample can be reproduced, 28 constant volume specimens were cast from two degassed induction furnace melts. Two series of constant volume molds dissimilar in volume were used in this investigation. All of the castings were solidified at atmospheric pressure.

The specimens thus obtained were processed and weighed as previously described. The specimens were weighed in air and ethyl alcohol (U.S.I. 200 proof). From these data their volume and density were then determined by Archimedes' technique.

The results of this work (Table 2) show that the constant volume sample can be reproduced within narrow limits. Maximum volume and density error obtained for the 20-cc sample was 0.054 cc and 0.007

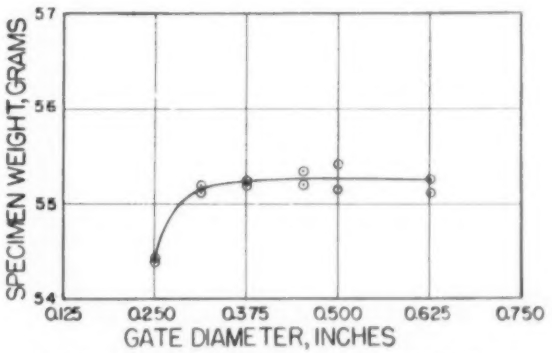


Fig. 6 — Gate diameter effect on the weight of the constant volume specimens. From the results obtained it can be seen that a minimum gate diameter of about 0.300 in. is necessary to insure satisfactory feeding of the castings.

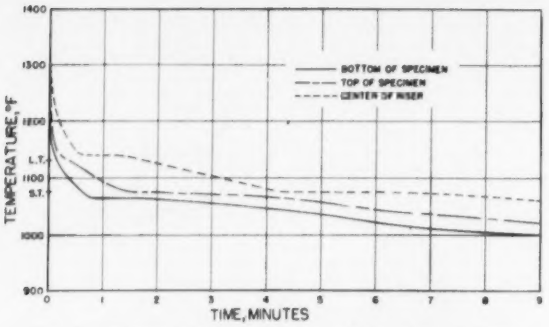


Fig. 7 — Temperature gradients within the constant volume casting when poured at 1300 F (alloy 356). The solidification of the specimen begins after approximately 9 sec, and ends slightly after 2 min. Complete solidification occurs after about 6¼ min.

gr/cc, respectively. These errors represent a gas content error of 0.004 cc of gas per 100 grams of metal (S.T.P.).

Standard volume and density deviation (σ) obtained was 0.028 cc and 0.003 gr/cc, respectively. These figures are equivalent to a gas content error of 0.002 cc of gas per 100 grams of metal (S.T.P.).

On the basis of the reproducibility data, a balance having a sensitivity of ± 0.05 grams, and a capacity in excess of 60 grams, would be adequate for all specimen weighings. Balances fulfilling these requirements are commercially available, and are sufficiently rugged for foundry floor use.

Solidification Time and Temperature Gradient Measurements

To determine the solidification time and the temperature gradients within the constant volume casting when poured at 1300 F, cooling curves were obtained. These curves were obtained by the use of a multipoint temperature recorder and three chromel-alumel thermocouples. One thermocouple was positioned in the center of the riser, and the other two were positioned just inside the top (⅛ - 3/16-in.) and bottom (1/16 - ⅛-in.) surfaces of the constant-volume specimen.

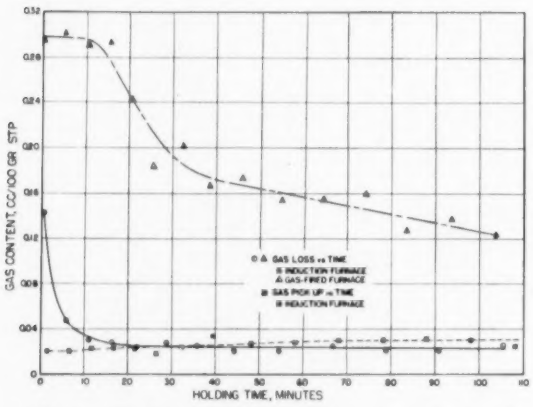


Fig. 8 — Gas loss and pickup vs. time curves for gassed and degassed heats of metal melted in induction and gas-fired furnaces.

TABLE 2—REPRODUCIBILITY TESTS RESULTS

Specimen No.	Vol. cc	Vol. Error cc	Density[1] gr/cc	Density[2] gr/cc	Density Error gr/cc
		Series 1			
1	19.792	−0.018	2.676	2.675	−0.001
2	19.819	+0.009	2.676	2.677	+0.001
3	19.815	+0.005	2.679	2.680	+0.001
4	19.769	−0.041	2.680	2.674	−0.006
5	19.756	−0.054	2.680	2.673	−0.007
6	19.801	−0.009	2.678	2.677	−0.001
7	19.819	+0.009	2.678	2.679	+0.001
8	19.778	−0.032	2.680	2.675	−0.005
9	19.853	+0.043	2.678	2.684	+0.006
10	19.823	+0.013	2.679	2.681	+0.002
11	19.847	+0.037	2.677	2.682	+0.005
12	19.830	+0.020	2.678	2.681	+0.003
13	19.828	+0.018	2.680	2.682	+0.002
14	19.769	−0.041	2.678	2.673	−0.005
15	19.829	+0.019	2.678	2.680	−0.002
16	19.815	+0.005	2.671	2.672	+0.001
17	19.840	+0.030	2.668	2.672	+0.004
18	19.823	+0.013	2.663	2.665	+0.002
19	19.790	−0.020	2.653	2.650	−0.003
	Average vol. of series 1 sample = 19.810 cc				
		Series 2			
20	19.472	−0.002	2.680	2.680	0
21	19.503	+0.029	2.679	2.683	+0.004
22	19.473	−0.001	2.680	2.680	0
23	19.443	−0.031	2.677	2.672	−0.005
24	19.452	−0.022	2.680	2.677	−0.003
25	19.461	−0.013	2.680	2.678	−0.002
26	19.506	+0.032	2.679	2.684	+0.005
27	19.487	+0.013	2.681	2.682	+0.001
28	19.466	−0.008	2.681	2.679	−0.001
	Average vol. of series 2 sample = 19.474 cc				

1) Density value obtained on individual specimens by Archimedes' Method.

2) Density value calculated by assuming the averaged vol. of the samples in each of the series.

The cooling curve obtained at each thermocouple location is shown in Fig. 7. From these curves it can be seen that solidification of the specimen begins after approximately 9 sec and ends slightly after 2 min. Complete solidification of the casting occurs after approximately 6¼ min.

Although complete solidification of the casting occurs after approximately 6¼ min, the casting can actually be removed from the vacuum chamber after 4 min, and the riser knocked off without producing any harmful effects. This is because at that time the specimen segment of the casting is completely solid, and the riser segment except for its center portion is also solid.

The thermal gradient studies show, as expected, that directional solidification does occur in the constant volume segment of the casting. This is desirable with respect to feeding of the test sample.

In addition, the results of this work show that the desired vacuum level is obtained in the chamber before solidification of the constant volume casting actually begins. Solidification of the sample begins after approximately 9 sec. With the reduced pressure tester used in this work a pressure of 80 mm of mercury was obtained in approximately 8 sec.

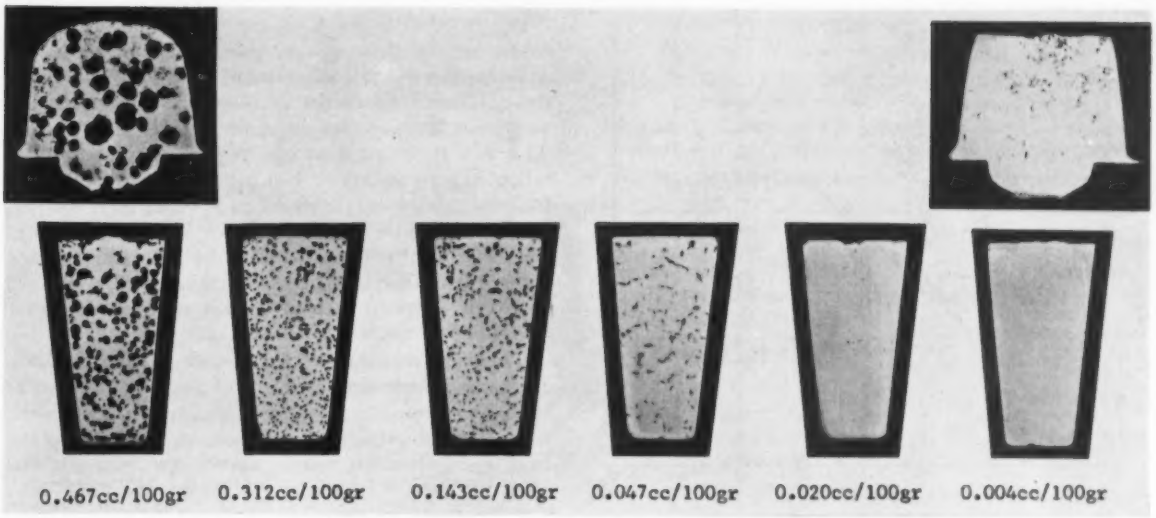


Fig. 9 — Sections of constant volume specimens showing gas contents over the range of 0.467 - 0.004 cc of gas (S.T.P.) per 100 grams of metal. The corresponding risers are shown for the specimens representing the extreme of the range.

Gas Loss and Pickup vs. Time

To determine how sensitive the constant volume sample is to a loss or pickup of gas in a melt, samples were cast at various time intervals from degassed and gassed heats of metal melted in the induction and gas-fired furnaces. All of the samples were solidified at a reduced pressure of 80 mm of mercury.

The volume of gas in the samples at standard conditions of pressure and temperature (S.T.P.) was calculated from the measured weight and the standard density of gas-free 356 alloy. These calculations were made by the use of the following formula (formula derivation given in Sec. 1 of Appendix):

$$\text{cc of Gas per 100 gr of Metal (S.T.P.)} = \frac{W_o - W_1}{W_1} \times K_s$$

where W_o = Weight of gas free sample
W_1 = Weight of reduced pressure sample
K_s = Constant

From the data obtained curves (Fig. 8) were prepared showing the sensitivity of the sample to the volume of gas present in the melts at various time intervals. The results of this work show that the constant volume sample is sensitive to a loss or pickup of gas in a melt. The curves obtained are quite smooth. The small amount of scattering obtained with the gassed gas-fired furnace melt is believed not to be due to the failure of the sample to accurately detect the loss of gas, but may be due to the fact that the melt temperature cycled during the holding time. Although all samples were cast at 1300 ± 5 F, the melt temperature throughout the run cycled between 1250 and 1350 F.

Figure 9 is a photograph of a series of sections of constant-volume specimens showing gas contents over the range of 0.467 - 0.004 cc of gas (S.T.P.) per 100 grams of metal. The corresponding risers are also shown for the samples representing the extreme of the range. Calculation of the apparent gas content of these risers (0.511 and 0.026 cc/100 gr) revealed that the riser segment contained a larger apparent volume of gas than the specimen.

An investigation was therefore conducted to determine whether shrinkage or gas segregation was responsible for this difference. Samples were cast containing various amounts of gas. These castings were solidified under a reduced pressure of 80 mm of mercury for 7 min. From the castings thus obtained, the density of the riser and specimen portions of the castings were determined.

The data obtained were plotted as shown in Fig. 10. Each point represents a specimen and riser density value obtained from one casting. Along with plotting the experimental points, a line was drawn representing the theoretical* specimen and riser density relationship line upon which all of the points should fall. From Fig. 10 it is evident that none of the points falls upon the line, and all are just below it.

Figure 11 shows the microstructure of specimen (a) and riser (b) segments of a relatively gas-free constant-volume casting. An examination of these photomicrographs shows the presence of shrinkage voids in the riser (b), which may be responsible for the excessively low riser density values. The density and gas content calculations made were made with the assumption that all voids present in the specimen and riser were due solely to entrapped gas.

The presence of shrinkage voids in the riser may possibly be explained on the basis that little if any directional solidification occurs in the plaster molded riser.

Sampling Temperature Effect

An analysis of the mechanism of hydrogen evolution[4] from solidifying aluminum alloy melts suggests that the sampling temperature may be a factor affecting the results obtained. When the gas level in the melt is high, higher sampling temperatures would sus-

*See Sec. 2 of Appendix for method used for calculating theoretical specimen and riser density values.

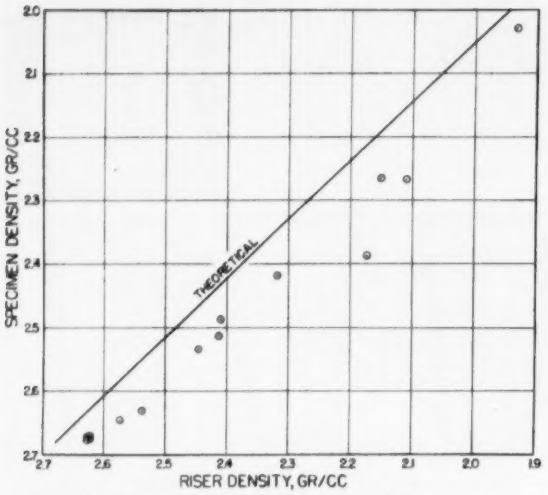


Fig. 10 — Experimental relationship between riser and specimen densities. The theoretical line is included for comparison purposes.

tain the sample in the liquid state for a longer time during the test, increasing the possibility for loss of gas through the metal surface. Practical difficulties, however, prevent a direct evaluation of this variable.

As an indirect method for determining whether sampling temperatures significantly affected the results, a series of melt samples were taken during the time interval that induction and gas-fired furnace melts[4] were being heated and cooled between 1220 and 1495 F. Approximately 34 min elapsed between taking the first and last samples in each melt. The samples were all solidified under a reduced pressure of 80 mm of mercury for 7 min. It was expected from previous holding time data that the gas contents would vary with time, and that if a temperature effect were detected it would manifest itself in an abnormal behavior in the gas content versus melt temperature relationship.

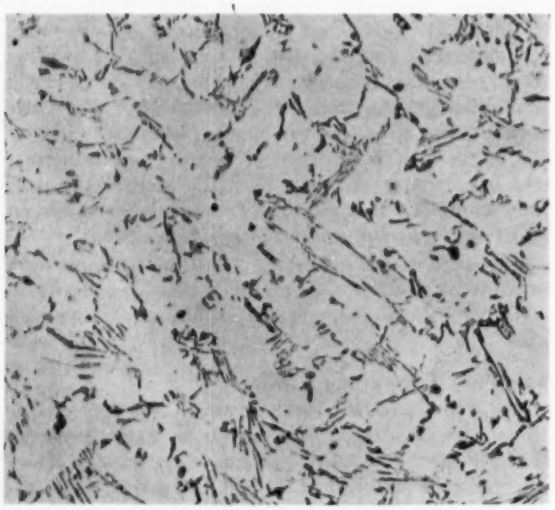
Figure 12 is a graph of the data obtained in the course of the heating and cooling experiments. An examination of this data shows that on heating in the gas-fired furnace the apparent gas content of the melt rises sharply with increase in melt temperature. This is a verification of the long recognized foundry taboo against excessive heating of aluminum melts. On cooling, the combination of lowered melt temperature and holding time results in a loss of gas from the melt. The melts prepared in the induction furnace showed a similar trend but at a greatly lowered level of gas, in keeping with previously observed behavior of induction melted aluminum alloys.

These observations conform with expected trends. It is apparent that rate of loss of gas is a function of time, temperature and the ambient atmosphere in the furnace. With due consideration of these facts, the heating and cooling curves for the gas melted metal (Fig. 12) show a hysteresis type function. Their relative positions indicate an understandable lag in gas pickup upon heating, and a similar lag in gas loss upon cooling. In the experiment conducted with induction melted metal, the gas level is sufficently low and the rates of gas loss sufficiently high (holding time experiment) that the hysteresis effect is not in evidence.

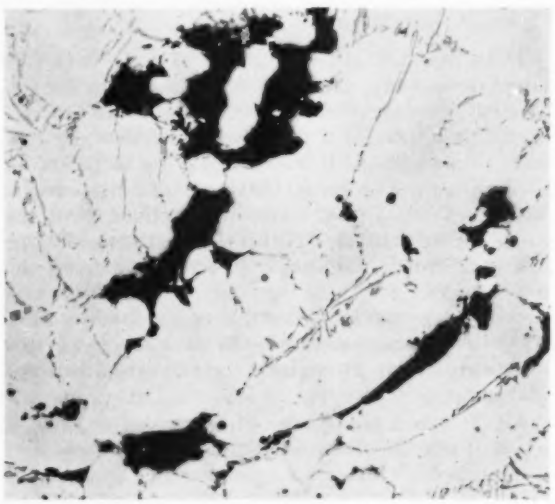
These data give no evidence of any significant gas loss at high sampling termperatures. Since the goal of the constant volume sample test for gas in aluminum melts is the detection of the point where the gas level approaches zero, it is apparent that loss of gas from a melt of low gas content cannot be a factor in the test.

Constant Volume Sample Reduced Pressure Test

This test is a quantitative test for determining the gas content of an aluminum-base alloy melt. With the constant volume sample, the volume of gas contained in a melt is determined from the weight of the sample, and the curve shown in Fig. 13. This curve shows the relationship of sample weight to cc of gas per 100 grams of metal (S.T.P.). The curve was ob-



a) Specimen (density 2.673 gr/cc).



b) Riser (density 2.628 gr/cc).

Fig. 11 — Photomicrographs of the specimen and riser segments of a constant volume casting showing the presence of shrinkage voids in the riser. Light 3% H.F. etch. 100 ×.

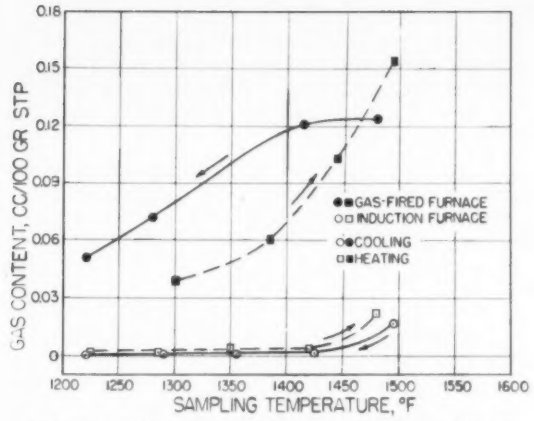


Fig. 12 — Effect of sampling temperature on the gas content of constant volume samples from induction and gas-fired melts. On heating in the gas-fired furnace the apparent gas content of the melt rises sharply with increase in melt temperature.

tained by solving the following equations:

$$\text{cc of Gas per 100 gr Metal (S.T.P.)} = \frac{P_2}{P_1} \times \frac{T_1}{T_2} \times 100\left(\frac{W_1}{V_1} - \frac{1}{D_0}\right)$$

It is evident from the procedure described that the test can be performed fairly rapidly. In actual practice, it has been found that the gas content of a melt can be obtained within approximately 4½ min.

The simplicity and rapidity of the test is such that it may be used as a production test for controlling the gas content of aluminum-base alloy melts in an industrial foundry.

Measured Gas Content vs. True Gas Content

The usefulness of the reduced pressure solidification test, whether for qualitative or quantitative measurement of gas in molten aluminum, has been demonstrated by its acceptance as a production foundry control test. The question may be raised, however, whether the calculated gas content based essentially upon the volume of voids found in the reduced pressure sample, is the true gas content of the melt. The answer to this question is no. This is so because the number obtained is based upon certain simplifying assumptions, which are related to the characteristics of the test and to the method of computation. These are:

1) That the solid solubility of hydrogen is negligible and that all the gas originally contained in the liquid is expelled during the test.
2) That none of the gas precipitated from the sample is lost.
3) That the voids in the sample contain gas at a pressure equal to the sum of the reduced pressure in the system plus the metallostatic head.
4) That the base density of the metal in the melt is accurately known.

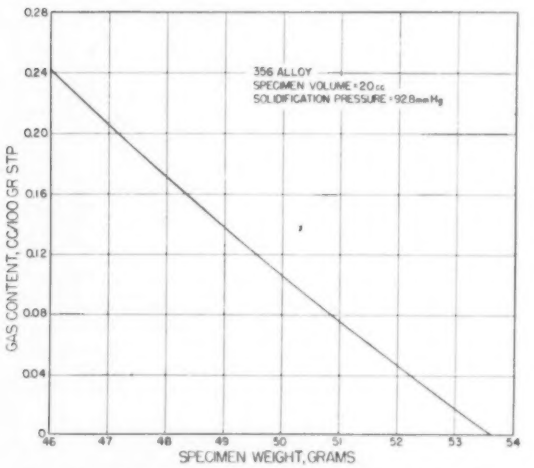


Fig. 13 — Curve showing the relationship of specimen weight to gas content (weight to cc of gas per 100 grams of metal, S.T.P.). The curve was obtained by solving equation given in paper.

There is much evidence that suggests that the use of these assumptions does not lead to any large error. Ransley and Neufeld[5] have determined that the equilibrium solid solubility of hydrogen in aluminum is small, being 0.036 cc/100 gr at 760 mm pressure, or approximately 0.012 cc/100 gr at the test pressure. Since the gas in solid solution does not produce unsoundness in the casting, its presence is not really a factor in the test. Rosenthal and Lipson[4] have shown that the total void volume varies with the atmospheric pressure over the samples as predicted by Boyle's Law.

If gas bubbles were to escape under reduced pressure, this relationship would not hold. The uniform distribution of the gas holes in the sectioned samples, shown in Fig. 9, is further evidence that there is no appreciable tendency for the gas bubbles to float to the surface of the sample.

The careful design of the specimen, together with its highly efficient plaster riser, minimizes the possibility for occurrence of shrinkage voids. The thermal gradient measurements are further evidence of this fact.

Variations in alloy chemistry within specification limits result in differences in base density. This would be a source of error when used as the basis for the gas content calculation. Under reduced pressure solidification of 0.1 atmosphere, this error is reduced by a factor of ten, and can be regarded as negligible.

On the basis of this discussion, it is apparent that the values obtained approximate the true gas content of the alloy. At any rate, the volume of gas, as determined from the sample, is that which is available to produce unsoundness in castings poured from the melt. One additional point should be made relative to the empirical value obtained in the test. The solid solubility of hydrogen at atmospheric pressure exceeds that at the test pressure by 0.024 cc/100 gr. Where the measured gas content of the melt is no greater than this value, it may be assumed that all of the gas in the metal can be retained in solution under conditions of atmospheric solidification.

CONCLUSIONS

1) Based on the reproducibility data, empirical values for gas content can be obtained with a standard deviation (σ) of 0.002 cc/100 gr. This value is based upon the following:
   a) Standard volume deviation (σ) of 0.028 cc in a 20 cc sample.
   b) Standard density deviation (σ) based only on the weight of the sample of 0.003 gr/cc.
2) The empirical gas content values determined by the test probably approximate the true gas content of the sample.
3) Sampling temperatures between 1250 and 1450 F have no apparent effect on the test results.
4) The constant volume sample reduced pressure solidification test can provide a quantitative measure of the gas contained in a melt within 4½ min. from sampling, and with equipment sufficiently rugged to permit use directly on the production foundry floor.

ACKNOWLEDGMENT

The authors are indebted to the Department of the Army for permission to publish this paper. The authors express their appreciation to H. Markus, Dir., Met. Rsch. Laboratory, and H. Rosenthal for their review and assistance in carrying out this work. The opinions expressed in the paper are those of the authors, and are not necessarily endorsed by the Department of the Army.

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APPENDIX

1) Calculation of volume of gas per 100 grams of metal assumption: All voids present in the sample are due to entrapped gas.

$$\text{cc of Gas in Sample} = \frac{W_o - W_1}{D_o}$$

where W_o = Weight of gas free sample, gr
W_1 = Weight of reduced pressure sample, gr
D_o = Density of gas free 356 alloy, 2.68 gr/cc

$$\text{cc of Gas per 100 gr of Metal} = \frac{W_o - W_1}{D_o} \times \frac{100}{W_1}$$

The volume of gas at standard conditions of temperature and pressure in accordance with Boyle's and Charles' Laws is as follows:

$$\text{cc of Gas per 100 gr of Metal (S.T.P.)} = \frac{W_o - W_1}{D_o} \times \frac{100}{W_1} \times \frac{T_1}{T_2} \times \frac{P_2}{P_1}$$

where T_1 = 273 degrees K
T_2 = Solidus temperature of the alloy, 852° K
P_1 = 760 mm of Hg
P_2 = Solidification pressure (vacuum pressure + metallostatic pressure, 92.8 mm of Hg

$$\text{cc of Gas per 100 gr of Metal (S.T.P.)} = \frac{W_o - W_1}{W_1} \times \frac{100 \times T_1 \times P_2}{D_o \times T_2 \times P_1}$$

$$\frac{100 \times T_1 \times P_2}{D_o \times T_2 \times P_1} = \text{Constant } K_s$$

Then,

$$\text{cc of Gas per 100 gr of Metal (S.T.P.)} = \frac{W_o - W_1}{W_1} \times K_s$$

2) Calculation of theoretical specimen and riser density assumptions:
   1) All voids present in the specimen and riser are due to entrapped gas.
   2) The same amount of gas exists in the specimen as in the riser

D_1 = Density of specimen (or riser)
D_o = Density of gas-free specimen (or riser)

$$D_1 = \frac{\text{Wt.}}{\text{Vol.}}$$

$$\frac{1}{D_1} = \frac{\text{Vol.}}{\text{Wt.}} = \frac{\text{Vol. of Metal + Vol. of Gas}}{\text{Wt. of Metal + Wt. of Gas}}$$

Neglecting the weight of the gas, then

$$\frac{1}{D_1} = \frac{\text{Vol. of Metal}}{\text{Wt. of Metal}} + \frac{\text{Vol. of Gas}}{\text{Wt. of Metal}}$$

$$\frac{\text{Vol. of Gas}}{\text{Wt. of Metal}} = \frac{1}{D_1} - \frac{1}{D_o}$$

$$\text{cc of Gas per 100 gr Metal} = 100\left(\frac{1}{D_1} - \frac{1}{D_o}\right)$$

$$\text{cc Gas per 100 gr Metal (S.T.P.)} = \frac{P_2}{P_1} \times \frac{T_1}{T_2} \times 100 \times \left(\frac{1}{D_1} - \frac{1}{D_o}\right)$$

$$\text{Specimen: cc of Gas per 100 gr Metal (S.T.P.)} = \frac{92.8}{760} \times \frac{273}{852} \times 100 \times \left(\frac{1}{D_s} - \frac{1}{2.68}\right)$$

$$= K_s\left(\frac{1}{D_s} - \frac{1}{2.68}\right)$$

$$\text{Riser: cc of Gas per 100 gr Metal (S.T.P.)} = \frac{84.1}{760} \times \frac{273}{852} \times 100\left(\frac{1}{D_r} - \frac{1}{2.68}\right) = K_r\left(\frac{1}{D_r} - \frac{1}{2.68}\right)$$

Since the same amount of gas exists in the specimen as in the riser then

$$K_s\left(\frac{1}{D_s} - \frac{1}{2.68}\right) = K_r\left(\frac{1}{D_r} - \frac{1}{2.68}\right)$$

Knowing the density of either the specimen or riser, the other can be calculated.

Technical Papers Appeal Both to Designers and Foundrymen

■ Technical papers being submitted for presentation at the 1959 Castings Congress indicate that approximately 25 per cent of them will be of direct interest to design engineers.

Each of the Society's major divisions and general interest committees has been requested to devote a portion of its program to designers and buyers of castings. The technical program will supplement the Engineered Castings Show which will demonstrate to designers and buyers what is being done in today's foundries.

Typical papers scheduled by the Gray Iron, Die Casting & Permanent Mold, Steel, Light Metals and Malleable Divisions:

Welding and Brazing Cast Iron for Mechanical Properties.

X364 Aluminum Die Casting Alloy.

Utilization of Radioisotopes in the Foundry Industry.

Relation of Microstructure and Composition on Machinability of 1-in. Rounds.

Ductility and Strength of High-Carbon Gray Irons.

Martensitic White Irons for Abrasion Resistant Castings.

Interrelation Between Stress Concentration and Castability.

Effect of Molybdenum on Elevated Temperature Properties of Gray Iron.

How Aircraft Designers Look at Light Metal Castings.

Malleable Iron — A Magnetic Alloy.

Each of the technical divisions compiles its own technical program for the Annual Convention. All papers submitted to the division must be approved by the Program & Papers Committee.

The goal of each division and general interest committee is to present the latest technical research and a well-balanced program.

A review of some of the titles indicate the broad range of papers submitted or proposed.

Gray Iron Division — Chemical Analysis of Gray Iron: Cupola Response to Changes in Blast Temperature, Moisture, Coke Rate and Direct-Fired Blast Heater; Foundries Can Produce Their Own Gray Iron Directly from Ore; Factors Influencing the Soundness of Gray Iron Castings (a review of some recent British Work by the British Cast Iron Research Association).

Die Casting Division — A Summary of Aluminum Permanent Mold Practice; Evaluation of Cast Surfaces for Roughness Standard; Permanent Molding of Gray Iron.

Sand Division — Critical Sodium Silicated Sand Formulations for Optimium CO_2 Molding; Experimental Determination of Specific Surface and Grain Shapes of Foundry Sands; Timing of Expansion Scab Formation; Sand Movement Compaction in Green Sand Molding; Tempering of Molding Sand.

Light Metals Division — Constant Volume Solidification Sample for Rapid Measurement of Gas in Aluminum; Principles of Producing Sound Light Metal Castings; Ultrasonic Attenuation in Cast Aluminum; Preliminary Appraisal of Bending Techniques for Evaluation of Cast Material and Structure; A Discussion of Modern Alloy; Correlation of Radiography, Microstructure and Mechanical Properties of Cast Thoriated Magnesium.

Steel Division — Reclamation and Dimensional Accuracy of Sodium Silicate Bonded Sand; Rapid Hydrogen Determination for Steel Foundry Control.

Brass & Bronze Division — Some Foundry Problems in the Development of a New Propeller Alloy.

Malleable Division — Specialized Quality Statistical Controls Improve Customer Satisfaction.

Fundamental Papers Committee — Dimensioning of Sand Casting Risers; A Rationalization of the Effect of Mass on the Tensile Properties of Castings.

Heat Transfer Committee — Modern Quenching Oils and Techniques for Heat Treating.

Safety, Hygiene & Air Pollution — Practical Planning for Non-Destructive Testing by Use of Radiation.

1959 Congress Papers Start in This Issue

■ First of the 1959 Castings Congress papers will be found in the preceeding section. MODERN CASTINGS will publish most of the 1959 papers, many of them before the Annual Convention in April. Articles will appear in complete form.

AFS 1896

news and views

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national news

Only Two Months Remain in Local Apprentice Competition

■ Just two months remain in 1959 for chapters and plants to complete local apprentice competition, warns AFS Education Director R. E. Betterley. All entries in the national AFS Robert E. Kennedy Memorial Apprentice Contest must arrive at the University of Illinois, Navy Pier, Chicago, not later than 5:00 pm March 16.

Chapters and participating plants are advised to finish local events by March 1 to meet the deadline for national entries.

Betterley has these suggestions to avoid delays:

- Appoint one person as the official contact for all correspondence concerning the contest as provided in the Memorial Apprentice rules and regulations. This person will receive all contest materials and instructions.
- Promptly return contest forms which include names of contestants and divisions entered. Patterns, blueprints, official identification tags and other material from the National Office cannot be forwarded until this form is received.
- Address all correspondence only to AFS Education Director, AFS National Headquarters.

Local Contests

Three types of local elimination contests are conducted: AFS chapter contests, individual plant contests and inter-plant competition.

Entries from plants located in the area where local AFS chapter contests are held must clear through that local chapter competition to be eligible for the national contest. Only one winner in each division can be submitted by an individual plant when that plant conducts its own contest. Three or more plants participating in inter-plant competition or local chapter contests may submit the best three entries in each of the five divisions of national competition.

The 1959 contest rules and regulations must apply to all local contests. Results of local chapter and plant contests must be certified to the AFS Central Office at time entries are forwarded for judging in national competition. Certifications must be signed personally by chairman of the local contest committee.

In local contests awards of any nature may be awarded at the discretion of the local contest committee. Expenses in these contests cannot be assumed by AFS. Cash prizes must not equal or exceed awards granted in the national competition. National awards are $100 for first place winners in each of the five divisions; second, $75; third, $50.

Apprentice Eligibility

Any apprentice or trainee who has not had more than five years pattern experience nor more than four years molding experience is eligible for national competition. Membership in the American Foundrymen's Society is not required either for the contestant or his employer.

Classes of Competition

Five divisions of competition are open—three in molding and two in patternmaking. They are: iron molding, steel molding, non-ferrous molding, wood patternmaking and metal patternmaking.

Industry Cooperates

Molding patterns for the contest have been supplied by Accurate Matchplate Co., Chicago. Finishing of molding patterns was done by Englewood Pattern Co., Chicago.

Master drawings for the patterns were made by Garvey Pattern Works, South Bend, Ind.

Judges for the national contest are selected by the Apprentice Contest Committee. Judges are outstanding foundrymen who donate their services in the interest of apprentice training.

Limited Supply of 1958 *Transactions* Available

■ A limited supply of 1958 TRANSACTIONS is available. All pre-publication orders have been mailed. Copies may be ordered from AFS Headquarters, Golf and Wolf Roads, Des Plaines, Ill. Member price is $10; non-members, $15.

Wisconsin Program Set for February

■ Latest foundry developments in gray iron, steel, malleable, pattern and non-ferrous categories will be outlined at the 22d Wisconsin Regional Foundry Conference.

Simultaneous sessions in these five divisions will be held Feb. 12-13 at the Schroeder Hotel, Milwaukee, under sponsorship of the AFS Wisconsin Chapter in cooperation with the University of Wisconsin.

L. J. Andres, Lawran Foundry Co., Milwaukee, is general chairman.

THURSDAY, FEB. 12

9:00 am Registration.

10:00 am *The Stake of AFS in Engineering Education*, Kurt F. Wendt, Dean, College of Engineering, University of Wisconsin.
Report from Our National President, AFS President L. H. Durdin.

10:50 am *Practical Methods of Controlling Foundry Noise*, H. J. Weber, AFS Director of Safety, Hygiene and Air Pollution Control.

12 noon *The Face of Lincoln*, Larry Clark, Wisconsin Lincoln Committee.

Sectional Meetings 2:15-3:45 pm

Gray Iron—*Effects of Steel Scrap in the Cupola Charge*, N. P. Lillybeck, Brillion Iron Works, Brillion, Wis.

Steel—*Recent Developments in Sand Testing with Reference to Steel Castings*, V. M. Rowell, Harry W. Dietert Co., Detroit.

Malleable—*CentraSteel—A High Modulus Cast Graphitic Steel* by W. B. Larson, C. F. Joseph, F. J. Webbere and R. F. Thompson, Research Staff, General Motors Corp., Detroit—to be presented by W. B. Larson.

Pattern—*The Use of Plaster and Gypsum Cements in the Pattern Shop*, M. K. Young, U.S. Gypsum Co., Chicago.

Non-Ferrous—*Shell Cores in the Small Foundry*, S. Denkinger, Shalco Corp., Connellsville, Pa.

Sectional Meetings 4:00-5:30 pm

Gray Iron—*Solidification and Risering of Gray Iron Castings*, M. C. Flemings, Massachusetts Institute of Technology, Cambridge, Mass.

Steel—*Steel Castings Can Be Made In Shell*, Panel discussion headed by R. Vinette, Outboard Motors, Inc., Milwaukee.

Malleable—*New Developments in Water-Cooled Cupolas*, Harold Schwengel, Modern Equipment Co., Port Washington, Wis.

Pattern—*Latest Pattern Developments*, J. E. Olson, Dike-O-Seal, Inc., Chicago.

Non-Ferrous—*Improved Trends on Casting Finish*, C. A. Sanders, American Colloid Co., Skokie, Ill.

Banquet

6:30 pm *The Mighty St. Lawrence—Sea-*

way to the World, Col. Arnold M. Maahs.

FRIDAY, FEB. 13

Sectional Meetings
10:00-11:50 am

Gray Iron—*Producing Good Ductile Iron,* C. K. Donoho, American Cast Iron Pipe Co., Birmingham, Ala.

Steel—*Advantages of Casting Design to Develop Highest Service Strength,* J. B. Caine, consultant, Cincinnati.

Malleable—*Porosity in Malleable Iron,* C. R. Sorenson, National Malleable & Steel Castings Co., Cicero, Ill.

Pattern—*Patterns for Malleable and Steel Foundries,* J. M. Kriener, Cleveland.

Non-Ferrous—*Making Better Aluminum Castings,* D. L. LaVelle, Federated Metals Div., American Smelting & Refining Co., South Plainfield, N.J.

12 noon—*Outlook for the Milwaukee Braves,* J. W. Mullen, Milwaukee Braves Baseball Club.

Sectional Meetings
2:30-4:00 pm

Gray Iron—*Hot Blast for Improved Cupola Operation,* D. E. Krause, Gray Iron Research Institute, Columbus, Ohio.

Steel—*How to Extend Electric Furnace Roof Life and Cut Costs,* C. E. Grigsby, General Refractories, Inc., Philadelphia.

Malleable—*Continuous Annealing,* L. E. Emery, Marion Malleable Iron Works, Marion, Ind.

Pattern—*New Profit Horizons with Plastics,* J. B. Ferguson, Allis-Chalmers Mfg. Co., Milwaukee.

Non-Ferrous—*Brass and Bronze Foundry Problems,* F. L. Riddell, H. Kramer & Co., Chicago.

Yugoslavian Foundrymen Tour American Plants

■ Ten Yugoslavian foundrymen selected from the country's six regional districts in November completed a six-week tour of American foundries. The foundry productivity team investigated ferrous and non-ferrous foundries to study the production methods.

Specific subjects under study were pattern and coremaking equipment, molding practice and equipment, foundry handling equipment, melting and cupola operation, foundry layout and mass production methods. The team was brought to this country under the auspices of the International Cooperation Administration.

Members of the visiting team were Zvonimir Gorjup, Ekrem Bukic, Antun Crneka, Djure P. Dimic, Antun Jelic, Aleksandar Z. Mihajlovic, Radomir J. Popovic, Vladimir Savic, Todor D. Stanojevic and Selam I. Ustamujic.

Plant Layout Course Shows How to Analyze Operations

■ Considerations for plant layout on the basis of present and future operations were detailed at the AFS Training & Research Institute course given Nov. 10-12 in Chicago.

Keeping of accurate and comprehensive records was stressed in the analysis of present and contemplated operations. Recommended records include production figures for five years broken down into each month for the past year and the selection of a typical month or quarter for comparative purposes.

A cost analysis is then made using profit and loss statements, detailed expense statements, department payrolls, route sheets, materials produced with typical charts, raw materials and cost per unit and analysis coverage.

Planning for future operations begins by analyzing a typical month with projections made for each type of work. Based on these figures the number of castings to be produced with the various requirements are obtained.

How to best produce the castings for future requirements is the final step. Production figures indicate to what degree operations can be mechanized or automated and the flexibility required. Other factors are the degree to which modern techniques can be adopted and what processes can be standardized, eliminated or improved to reduce costs. In light of these factors what extent can be made of present facilities and equipment?

Six phases of plant layout were discussed—site and location, general layout, departmental layouts, buildings and services, safety and miscellaneous. Emphasis was placed on departmental layouts, taking into consideration the manufacturing and processing steps as well as non-production activities contributing to the production of castings.

Sessions on equipment selection were devoted to writing of specifications, invitations for bids and analysis of proposals, recommendations for purchase, availability of utilities and services, accessibility and extent of automation.

Efficient equipment applications were illustrated through films and case histories.

H. J. Weber, AFS Director of Safety, Hygiene and Air Pollution Control, explained requirements for safety and hygiene in plant layout. Other instructors were J. G. Poleck, J. H. Bertrand and Lester B. Knight, all of Lester B. Knight and Associates, Inc., Chicago.

How foundry plant layout can be improved is discussed at **T&RI course.** Left to right: **Frank S. Ryan,** St. Paul Brass Foundry Co., St. Paul, Minn.; **Carter Crookman,** Iowa Valve Co., Oskaloosa, Iowa; **Charles Peterson,** Eck Foundries, Inc., Manitowac, Wis.; **Irvin Godwin,** Iowa Valve Co., Oskaloosa, Iowa; instructors **J. G. Poleck** and **J. H. Bertrand,** Lester B. Knight Co., Chicago.

ANNOUNCING

1959 Training Courses •

Sponsored by AFS Training and Research Institute

Course No.	Subject and Description	Dates	Course Length (Days)	Where Given	Course Fee
M3A	**Cupola Melting of Iron** ..... Instructional course for cupola operators, supervisors, metallurgists and foremen. Basic principles for efficient cupola operation are studied with emphasis on cost reduction. Raw materials, cupola design, combustion control, metallurgy of cast iron, maintenance and new developments.	Feb. 2-6	5	Chicago	$90
M1A	**Melting of Copper-Base and Light Alloys** .. Course of instruction for melters, supervisors, metallurgists and foremen. Nomenclature, alloy classification, melting fundamentals, equipment, controls, testing and raw materials. Basic control variables are considered in light of optimum results.	Feb. 16-18	3	Chicago	$60
GR1A	**Gating & Risering of Castings** ..... Instruction course covering theory and practice on the various problems relating to gating and risering. Metal flow, solidification phenomena, heat transfer, shrinkage, hot tears, ferro-static pressure, gate and riser design, mold wall movement, and surface tension are some of the many facets considered. Intended for foremen, technicians, foundry engineers, supervisors, industrial engineers, and production and quality control personnel.	Feb. 23-25	3	Birmingham, Ala.	$40
MTY1A	**Metallography of Ferrous Metals** ..... Demonstration and work shop course for melters, supervisors, foremen, foundry engineers, researchers, laboratory technicians, metallurgists and design engineers. Basic metallurgy, terminology, phase diagrams, micro and macro analysis, physical properties based on metallographic interpretation and heat treatment are studied. One day of the course is spent on demonstrations and workshop activities in the laboratory. Metal specimens are prepared and analyzed.	Mar. 9-11	3	Chicago	$80
MET1A	**Metallurgy of Gray Iron**.... Intensive instruction on the basic metallurgy of gray iron. Metal compositions, alloys, physical and mechanical properties. Photo-micrographic examples are shown with the interpretation of microstructures. Controlling mechanical properties. For melters, metallurgists, engineers, researchers, supervisors and management.	May 25-27	3	Chicago	$60
MTY2A	**Metallography of Non-Ferrous Metals**.... Demonstration and work shop course for melters, supervisors, foremen, foundry engineers, researchers, laboratory technicians, metallurgists and design engineers. Basic metallurgy, terminology, phase diagrams, micro and macro analysis, mechanical properties based on metallographic interpretation and heat treatment are studied. One day on demonstrations and workshop activities in the laboratory. Metal specimens are prepared and studied.	July 13-15	3	Chicago	$80
SC1A	**Core Sand Practice** ..... Instruction covering all phases of materials, mixing and application. The advantages and disadvantages of new materials and methods are studied. Casting losses attributed to cores are analyzed for solutions. Foremen, supervisors, technicians, engineers and management.	Aug. 10-14	5	Detroit or Chicago	$90
GR1B	**Gating & Risering of Castings**..... Instruction course covering theory and practice on the various problems relating to gating and risering. Metal flow, solidification phenomena, heat transfer, shrinkage, hot tears, ferro-static presure, gate and riser design, mold wall movement, and surface tension are some of the many facets considered. Intended for foremen, technicians, foundry engineers, supervisors, industrial engineers, and production and quality control personnel.	Aug. 24-26	3	Chicago	$60

REGISTRATION NOW OPEN. Make reservations for all 1959 Training Courses by Course Numbers and dates given. Registations accepted in order as received.

ANNOUNCING

• 1959 Training Courses

Sponsored by AFS Training and Research Institute

Course No.	Subject and Description	Dates	Course Length (Days)	Where Given	Course Fee
PM1A	**Patternmaking** ..... Demonstrations and instruction for patternmakers, foremen, supervisors, trainees, purchasers of castings, suppliers and management. Materials, equipment, layout, allowances, construction techniques and recent trends. Emphasis placed on new materials, processes, techniques and their application.	**Sept. 16-18**	3	Chicago	$80
PD1A	**Product Development and Marketing**.... Instruction course on product analysis from the design to the marketing of the finished product. Study will include: casting design, stress analysis, pattern selection, equipment, cleaning operations, cost analysis, casting processes, engineering properties of cast metals, and sales promotion. Scheduled for all types of foundry engineers, sales engineers, technicians, supervisors, metallurgists and management.	**Sept. 28-30**	3	Chicago	$60
SAF1A	**Reducing Concealed Costs Through Safe Practices** ..... Demonstration and instruction course on savings that can be made through a knowledge of Workmen's Compensation, ventilation, radiant heat, occupational disease, safety in plant design, etc. Plants have little control over insurance premiums. These costs represent only 25 per cent of the actual costs sustained. Informed management can control 75 per cent of these costs. Appropriate for top management, supervisors, engineers and safety men.	**Oct. 5-7**	3	Chicago	$60
PRM1A	**Preventive Maintenance** ..... Intensive instruction on the "why" and "how" of a preventive maintenance program. Danger points in mechanized foundries having automatic and semi-automatic equipment. Cutting costs and reducing "down time" with an adequate maintenance program. Valuable assistance for foremen, supervisors, superintendents and management.	**Oct. 26-28**	3	Chicago	$60
PMD1A	**Permanent Mold & Die Casting**..... Both theory and practice are emphasized in this course of instruction for foundrymen interested in learning the latest developments in their growing fields. Molding materials, gating, and risering, new alloys, methods, equipment and product application.	**Nov. 9-11**	3	Chicago	$60
S2A	**Sand Control and Technology** ..... Instruction course for foundrymen having had some experience in sand testing, control and technology. Mold wall movement, hot deformation, creep deformation, mold atmosphere, heat transfer, mechanical properties and metal penetration are included. Students bring case problems to class for discussion and solution.	**Nov. 30-Dec. 4**	5	Chicago	$90
IE3A	**Industrial Engineering (Advanced)** ..... Instruction and workshop course for personnel experienced with basic industrial engineering principles. Practical cost control procedures applied to foundry operations, including work sampling, rating practice and statistical quality control. New techniques in industrial engineering are considered for foundry application. Industrial engineers, cost control personnel, quality control engineers, supervisors and management.	**Dec. 7-11**	5	Milwaukee	$150

Payment of Tuition Fees Should accompany enrollment application. Make all reservations ONLY with Director, AFS Training & Research Institute, Golf & Wolf Roads, Des Plaines, Ill. Tel. VAnderbilt 4-0181.

Purdue Metals Castings Conference

Emphasizes Cost

■ Utilization of cost-saving techniques occupied foundrymen during the Purdue Metals Castings Conference held Oct. 30-31 at Purdue University, Lafayette, Ind.

W. E. Patterson, Elkhart Foundry & Machine Co., Elkhart, Ind., served as chairman for the conference sponsored by AFS Central Indiana and Chapters and Purdue University. Dallas Lunsford, Perfect Circle Corp., Hagerstown, Ind., was program chairman. Meetings were held in the recently completed $8,650,000 Memorial Center for the first time.

Prior to the opening session E. W. Comings, School of Chemical and Metallurgical Engineering, Purdue University, welcomed foundrymen. Former AFS president Harry W. Dietert, Harry W. Dietert Co., Detroit, presented the response. Dietert said that the castings industry is ready to meet the challenge of new processes, new materials and new techniques. He pointed out that the AFS technical conferences, local technical chapter meetings, convention technical sessions, dissemination of technical information and T&RI activities assure the foundry industry of leadership in progress.

Sand Handling Panel

A panel discussion of sand handling opened the technical meetings. Participants were Robert Clarke, Dalton Foundry, Warsaw, Ind.; John Fulwiter, Fabricast Div., GMC, Bedford, Ind.; and T. W. Seaton, American Silica Sand Co., Ottawa, Ill.

Clarke explained sand handling systems used at Dalton in gray iron and malleable shops. With continuous pouring operations in the gray iron shop, a pneumatic system has been highly satisfactory. This has not been used in the malleable foundry where molding is done in the morning, pouring in the afternoon and shakeout at night. Clarke emphasized that sand is a big cost factor in any foundry but that handling systems must be adapted to individual plant problems.

Fulwiter commented on the six sands used in the Fabricast plant for molds and cores in aluminum castings. Sand processing was described for the main coreroom, shell resin cores and molding sand. All sand is reclaimed through a wet process unit. The seven major sand problems are: general dirt, expansion cracks, sand wash, core gas, cope drops, core knockout and finish.

Seaton contended that most foundry sand handling problems are due to a lack of attention to details. Sand, regardless of the amount, segregates each time it is moved. Solutions include using the pie-cutting technique on sand stockpiles, numerous small piles or incorporating a number of holes near the discharge end of silos.

Non-Ferrous Sessions

Major problems of dissolved gasses, creation of oxides and control of metal temperatures can be solved to a great extent by observing six major rules, Harry Ahl, Malleable Fittings Co., Branford, Conn., stated. Recommendations:

- Use and charge only materials of known composition.
- Use only clean furnaces or crucibles.
- Melt as quickly as possible.
- Melt in a near neutral or slightly oxidizing furnace atmosphere.
- Do not superheat.
- Skim carefully.

Two further recommendations were made for simple, cheap quality control measures: the AFS fracture test and the zinc test for determining atmospheric condition.

Principles of gating, ferrous as well as non-ferrous, are based on laws of hydraulics, said J. G. Kura, Battelle Memorial Institute, Columbus, Ohio. The extent to which these principles are applied varies with the type of metal, casting design and cleanliness desired.

National Director **C. A. Sanders,** banquet speaker at **Purdue Conference.**

Kura emphasized that answers to gating problems are found in published literature and recommended that foundrymen take advantage of research work.

Ferrous Sessions

The practice of inoculating gray cast iron will increase as the demands for high metallurgical quality become more stringent stated R. A. Clark, Electro Metallurgical Co. Div., Union Carbide Corp., Cleveland.

Ladle additions to metal of unpredictable composition resulting from poorly controlled cupola practices should not be expected to produce high grade iron of controlled properties. However, inoculation is a time-proven tool which the iron foundryman can make a useful part of his melting practice.

Highly satisfactory results from ductile iron operations at the John Deere Malleable Works, East Moline, Ill., were reported by Eric Welander.

One year ago Welander told the conference of plans for the installation which has exceeded expectations and increased production is planned.

No lining is used in the water-cooled cupola. Essentially the system

Purdue Conference was held for first time in $8,650,000, six-story **Memorial Center** with 550 rooms devoted to university activities and adult education.

Former AFS President **H. W. Dietert** (center) delivered opening address. Flanking Dietert are program chairman **Dallas Lunsford** and conference chairman **W. E. Patterson.**

Members of **Purdue Conference Committee,** front row: **H. B. Verhees,** Mishawaka, Ind.; **D. F. Lunsford,** Perfect Circle Co., Hagerstown, Ind.; **W. E. Patterson,** Elkhart Foundry & Machine Co., Elkhart, Ind.; **T. E. Smith,** Central Foundry Div., GMC, Danville, Ill. Back row: **J. C. Maggart,** Sibley Machine & Foundry Co., South Bend, Ind.; **C. T. Marek,** Purdue University; **K. E. Glancy,** Purdue University; **P. M. Semler,** Auto Specialties Mfg. Co., St. Joseph, Mich.

uses a shell within a shell with the 7-in. gap filled with water giving a more uniform melting rate. Water-cooled tuyeres and a hot-blast system are also incorporated.

Future applications probably will include replacing heavy-sectioned castings in malleable, pearlitic and gray iron. Further possibilities are castings difficult to produce in other materials prone to crack, forgings and weldments.

Banquet

European foundries are winning the technology race, C. A. Sanders, American Colloid Co., Skokie, Ill., warned at the banquet. Slides of European practices demonstrated some of the new processes and techniques. Development of new methods, close attention to the smallest details in manufacture, and lower wages combine to make cheaper, high quality castings from European foundries.

Lack of operational data is one of the three major factors responsible for 24 American foundries becoming bankrupt in 1957 with liabilities of $1,848,000. During the first six months of 1958, 20 foundries became bankrupt with liabilities amounting to $4,299,000. These figures were quoted by A. C. Sinnett, Terre Haute Malleable & Mfg. Corp., Terre Haute, Ind., to show that accounting procedures have not kept pace with foundry production engineering.

Sound costs should go beyond department costs and are applied to centers of operation within departments. This provides both small jobbing foundries and highly mechanized shops with casting costs which include only elements required for production in the case of each pattern and excludes costs for facilities which are not used.

Importance of non-destructive testing is growing as tighter customer specifications are being used, pointed out Harry L. Day, Auto Specialties Mfg. Co., Benton Harbor, Mich.

Testing methods for hardness, soundness and metallurgical conditions were reviewed. Hardness testing includes Brinell, Rockwell, and new electrical and electro-magnetic techniques. Among surface and internal soundness testing methods are magnetic particle, electro-magnetic radiation, sonic and ultrasonic. Other tests include strain gages, hydraulic, despruing and ferromagnetic.

Diversification Panel

Diversification of processes–Sam Holden, Golden Foundry, Columbus, Ind. Incorporation of various processes is necessary to meet competition. An aggressive offense is essential to meet competitive methods of fabrication. It is necessary also because no one process can do all jobs best.

Diversifying the Customer–William Truckenmiller, Albion Malleable Iron Co., Albion, Mich. Diversification is essential because of erratic demands of certain segments of industry and to stabilize the labor market. Before seeking additional or varied customers it is essential to analyze the present capabilities such as physical facilities, size limitations, tonnage limits, control procedures, manpower, training programs, fiscal position and development capabilities.

Need and willingness to serve the customer–Walter A. Szott, Central Foundry Division, GMC, Danville, Ill. The increasingly rigid lines drawn on quality and tolerances by customers is a polite way of saying, "Produce or else."

Positive approaches which may assure customers of efforts to meet their demands are:

- Statistical control.
- Improved inspection methods and devices.
- Customer follow-up.
- Cooperative engineering.

Robert Clark, Dalton Foundry, Warsaw, Ind., speaking on sand handling. Technical chairman **T. E. Smith,** Central Foundry Div., GMC, Danville, Ill., on left.

Northwest Regional Conference

Shows How Foundries

■ We can't depend on present day customers to perpetuate our business. For example, look at what happened to stove castings, steam locomotives, sash weights and chilled iron railroad car wheels. We must look to new uses for castings, for new markets, otherwise we will be a shrinking industry.

This was the warning to 181 foundrymen at the Northwest Regional Foundry Conference by AFS Technical Director S. C. Massari. Cures advanced by Massari were better metallurgical control, more dimensional precision, greater stress on engineering and marketing.

What the foundry industry is doing to meet competitive forces was outlined by speakers who emphasized the conference's theme—"Let's Build Today's Foundry." Sponsoring the conference were the AFS British Columbia, Washington, Oregon and Oregon State College Student Chapters. F. M. Menzel, Rich Mfg. Co., Portland, Ore., served as general chairman and A. A. Belusko, Electric Steel Foundry Co., Portland, Ore., was program chairman for the 9th annual conference held Oct. 31-Nov. 1 at the Hotel Multnomah, Portland, Ore. Summaries of technical talks:

A New Approach to Foundry Automation, Alex H. Homberger, International Automation Corp., Ann Arbor, Mich. A precise formulation of problems is the first step to automation. In the Buhrer method studies led to the selection of clay-bonded silica as the molding media. Next, various molding compaction methods were reviewed including vibration, squeeze or static pressure, blowing and slinging and jolting. The latter was selected, using a measured head of sand.

Plant Layout, R. L. McIlvaine, National Engineering Co., Chicago. Foundry layout is of particular importance because it is one of the few avenues left to a foundryman to improve efficiency and reduce costs by using his ingenuity. When considering a change in layout or arrangement, do not lose sight of the main purpose in the effort for the sake of enjoying as many side benefits as possible. Supervisors must understand and be in sympathy with the proposed changes.

Fred Menzel, Rich Mfg. Co., Portland, Ore., general conference chairman, opens 9th Annual **Northwest Regional Conference.**

Materials Handling Panel

Lift Trucks, John Given, Hyster Co., Portland, Ore. Materials handling man-hours in foundries are the maximum for any industry. Handling does not add to the value of any product; efficient handling is the only means of cutting this expenditure. Foundries should have a carefully compiled overall plan, then install equipment step-by-step with this plan. In some foundries, installation of sand and mold handling systems has increased production 200 per cent in the same floor area.

Cranes, Paul T. Kraus, Harnischfeger Corp., Milwaukee. It is poor economy to purchase cranes too far under or over actual requirements. Overloading equipment is being done by too many foundries. Kraus listed five classifications of cranes with their capacities and uses. Moderate duty cranes answer 75 per cent of the service requirements for small foundries. Capacities range up to 15 tons with two to 20 maximum capacity lifts per hour.

Conveyors, R. J. Geitman, Link-Belt Co., Chicago. Good engineering and proper layout design is just as important as equipment selected. Conveyor layout should be developed to produce a straight-line flow for study and discussion with the foundry personnel, including foundry superintendent, foundry engineers and the entire top administrative staff. After a desireable flow has been established a more detailed layout can be developed, keeping in mind flexibility is of utmost importance in developing the overall conveyor layout from raw materials to finished products.

Every foundry is different and presents its own problems, which should be studied individually with the help of engineers.

Work Simplification, J. R. Irish, Texas Foundries, Inc., Lufkin, Texas, concluded the opening day's technical sessions. Work simplification shifts emphasis from experts to each and every member of the organization, overcoming resistance and resentment to change. Texas Foundries uses such simplification tools as pegboard, flow process chart, multiple activity chart and left and right hand charts. Classes are held for both hourly and supervisory employees with hourly employees being paid at their regular rate. Instruction instills in employees' minds a questioning attitude about any job and teaches step-by-step procedures for improving that job.

New Core Processes panel with Chairman **Stan Marshall** accepting questions from audience.

Banquet

Fred Smith, Fred Smith Associates, Cincinnati, was the featured speaker, discussing *Human Relations in Industry*. W. G. Walkins, Electric Steel Foundry Co., served as toastmaster. AFS Vice-President C. E. Nelson also addressed the banquet.

New Core Processes

Shell Cores, R. M. Ronne, Dependable Pattern Works, Portland, Ore.

Are Meeting Challenge

Shell cores give accuracy, permeability, collapsibility and easy shakeout. They are consistently accurate in dimensions without sag or deformation. The shell process lends itself to coremaking as well, or even better, than molding. Cores are made and finished in one operation without driers, ovens or pasting. There is no difference in the release properties of different metals provided boxes are treated with proper release agents. *CO_2 Cores*, Dean Shull, Pure Cabonic Co., New York. The CO_2 process does a good job with all types of metals but is not a cure-all. No special core boxes are needed but metal boxes are preferred because of the better releasing properties of metal. Sand can be hand rammed

Luncheon speaker **Stephen M. Shelton,** Oregon Metallurgical Corp., Albany, Ore., speaking before **Northwest Regional Conference.**

or blown and gassing accomplished either manually or by metered mechanical equipment. Mixing must be done as quickly as possible and the sand should be protected from the atmosphere.

Cold Set Cores, E. S. Valentine, Reichhold Chemicals, Inc., South San Francisco, Calif. Cold set cores give good accuracy of reproduction and no distortion in baking. They have the advantage of high sand flowability since no cereals or moisture is involved. Faster coremaking saves man-hours, especially on large cores. The process is adaptable to molding in certain cases but is not designed for high speed production either in molding or coremaking. Sand must be dry and clean as cold setting properties are inhibited in the presence of moisture, clay and fines.

Luncheon, S. M. Shelton, Oregon Metallurgical Corp., Albany, Ore., spoke on *Operation and Development of Oregon Metallurgical Corp.*, predicting a healthy, growing market for "wonder metals." Applications to date have been chiefly in the supersonic aircraft and missile field.

Foundry mechanization explained by **R. L. McIlvaine,** National Engineering Co., Chicago. **Frank H. Jefferson,** Frank H. Jefferson, Inc., Seattle, Washington Chapter Secretary, serves as technical chairman.

Molding Methods Panel

Shell Molding, John Oettinger, Electric Steel Foundry Co., Portland, Ore. The shell process is easier to mechanize than other processes, cuts down on human error, achieves closer tolerances with a low percentage of rejects and good surface finish. Profitable production is possible in both large and small shell operations. More resins will be used as additives making mixes more expensive. Nevada and Ottawa sands are most widely used in the west, with coated sands becoming increasingly popular. Pattern equipment is metal, usually iron or bronze.

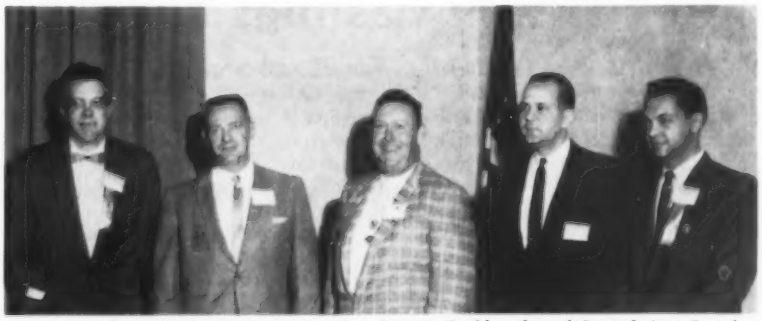
CO_2 Molding, Dean Shull, Pure Carbonic Co., New York. The CO_2 coremaking and molding methods are basically the same; CO_2 sand can be used for the whole mold, for a full facing or for a localized facing in certain mold parts. The full mold is considered uneconomical since the sand is not reuseable; however, reclaim systems are presently being developed. Use of heated CO_2 gas has been tried successfully, doing away with the danger of moisture condensation from atmosphere and achieving a better spread of gas due to increased volume.

Sandslingers, Harold Pridmore, Beardsley & Piper Div., Pettibone Mulliken Corp., Chicago. Great flexibility and variety of sizes make sandslingers adaptable to all sizes of foundries and may be used for turntable production or large and small jobbing work utilizing stationary and motives types.

Ceramic Molding, Leonard Dean, Berea Iron Foundry, Inc., Cleveland. Castings have been poured up to 300 lb but the average weight is 30 lb. Standard patterns are used but gating and risering must be altered as well as pouring practice. Curing time varies with the size of the molds. Small molds will cure in 20 min to two hours. Special melting equipment is not needed. The ceramic process is in its infancy but shows promise, especially for smoother surfaces and closer detail in cored passages.

Permanent Molding, Joe W. Goehler, Central Brass & Iron Foundry, Portland, Ore. Permanent molding is a flexible process adaptable to automation or turntables with dimensional accuracies obtainable to 0.001 in. All types of cores are adaptable with green sand cores given the poorest results. Since aluminum doesn't lay well on metal-to-metal surfaces, mold coatings are used which also control directional solidification. Graphite or carbon black are commonly used. Insulating materials of various types are often used, the type depending upon the surface finish desired.

MODERN CASTINGS thanks William G. Walkins and Norman E. Hall, Electric Steel Foundry Co., Portland, Ore., for editorial and photographic coverage used in preparing this article.



Comparison of molding methods panel included **J. W. Goehler,** Central Brass & Iron Foundry, Portland, Ore.; **Leonard Dean,** Brea Iron Foundry, Inc., Cleveland; **Harold Pridmore,** Beardsley & Piper Div., Pettibone Mulliken Corp., Chicago; **Dean Shull,** Pure Carbonic Corp., New York; and Chairman **John Oettinger,** Electric Steel Foundry Co., Portland, Ore.

national news

Spanish Foundrymen Host to 1959 International Congress

■ Historic Spain will be host to the 26th International Foundry Congress sponsored by the International Committee of Foundry Technical Associations.

The International will be held Oct. 3-10, 1959, in Madrid and Barcelona under sponsorship of the Spanish Institute of Iron and Steel.

Tentative plans call for technical talks and conferences, receptions, ladies program, tours and plant visitations, inauguration of new installations at the Institute of Iron and Steel in University City and post-Congress tours.

AFS will sponsor a tour specifically designed to meet the interests of American foundrymen. Details will be carried in future issues.

In addition to the **1959 International Congress,** visitors in Spain will find beautiful scenery, historical cities and ruins and a diversity of customs, costumes and crafts in each region. Photo shows one of the centuries-old ruins for which Spain is famous.

Invite 50,000 Designers to Attend 1959 Castings Show

■ Opening guns have been fired in the 1959 industry-wide battle by foundries to increase their share of the metal fabrication market. More than 50,000 design engineers throughout the United States have been contacted by AFS with the message—"Castings can do a better job for less."

Next step in the campaign is to show designers what the industry can do. The stage for this demonstration will be the 1959 Engineered Castings Show to be held April 13-17 at the Sherman and Morrison Hotels, Chicago.

Space applications continue to be received for foundrymen realizing that this is industry's prime contact with the designers and buyers of castings.

Limiting exhibitors to four classifications allows concentration on the Show's target—design engineers and buyers. Firms eligible to exhibit are those:

- Producing castings for sale.
- Producing patterns for sale.
- Manufacturing laboratory, testing and inspection equipment for control of casting quality.
- Producing metals and alloys inherent in quality castings.

"Designers not only have to be told the advantages of castings, they also have to be shown," says W. N. Davis, AFS Exhibit Manager.

"Designers are interested in what the entire foundry industry can perform. This is the one place where all classifications of metals, molding techniques, processes and casting engineering services can be demonstrated to the best advantage."

Other plus factors as listed by Davis:

- The Show gathers together the buyer, designer, patternmaker and foundrymen to discuss mutual problems.
- Freedom from everyday pressures and interruptions can be avoided.
- Redesigns and conversions can be demonstrated and discussed.
- Low cost of numerous potential sales contacts with buyers and designers.

Exhibitor housing applications and advance registration forms will be mailed during the week of Jan. 19.

T&RI Outlines 1959 Program

■ Fifteen courses have been tentatively scheduled for the AFS Training & Research Institute program for 1959. Additional courses are expected to be presented in cooperation with chapters but final details have not been completely arranged.

Five new courses will be added: *Metallurgy of Gray Iron, Gating & Risering of Castings, Preventive Maintenance, Permanent Mold & Die Casting* and *Electric Furnace Melting of Iron.* These additions have been made in line with the policy of continually broadening T&RI coverage.

Courses being repeated due to industry response are: *Cupola Melting of Iron, Melting of Non-Ferrous Alloys, Metallography of Ferrous Metals, Sand Testing, Metallography of Non-Ferrous Metals, Patternmaking, Product Development, Cost Reduction by Safe Practices, Sand Control & Technology and Industrial Engineering.*

A description of course subjects, dates, locations and fees will be found on page 114-115.

chapter news

Metropolitan Chapter

Honors Past-Chairmen

■ A combined National Officers and Past-Chairmen's night was conducted at the November meeting. National Officers attending were President L. H. Durdin, Secretary A. B. Sinnett, Regional Vice-President H. G. Stenberg, National Director A. A. Hochrein and National Director C. A. Sanders who was also the technical speaker.

AFS National Director **C. A. Sanders,** chats with Metropolitan Chapter Vice-Chairman **Robert B. Fischer,** Ingersoll-Rand Co., Phillipsburg, N.J. at November meeting.—*John Bing*

Past Metropolitan chairmen were awarded certificates of appreciation. Those receiving their awards in person:

D. J. Reese (1938-39)
International Nickel Co.
H. L. Ulrich (1946-47)
Sacks-Barlow Foundries, Inc.
J. A. Bukowski (1948-49)
Worthington Corp.
D. S. Yoemans (1950-51)
Geo. F. Pettinos, Inc.
J. S. Vanick (1953-53)
International Nickel Co.
C. Schwalji (1954-55)
Worthington Corp.

Metropolitan Chapter Chairman **William T. Bourke,** American Brake Shoe Co., Mahwah, N.J. and AFS President **L. H. Durdin.**

Seated at head table are Regional Vice-President **Henry G. Stenberg,** National Director **A. A. Hochrein** and Chapter Vice-Chairman **R. R. Fischer.**

C. D. Preusch (1955-56)
Crucible Steel Co.
H. Voit (1956-57)
Sterling National Industries.

There appears to be more national research and development data available in North America than in Europe but more individual foundry research is growing in Europe, Sanders told the audience. The chemist and chemical engineer are gradually replacing the metallurgist in certain areas of European technology.

Two direct types of ore reduction were outlined. Those using gaseous reducing agents in a fluidized reaction and those performed in kilns, retorts or shaft furnaces. These have possibilities of being extended to foundry use.

Other subjects covered by Sanders in describing European practices were: melting processes; vibration treatment of metals; heat treatment; and apprentice training.—*C. H. Fetzer*

New England Chapter

Profitable Use of Air Tools

■ How to efficiently use compressed air tools was explained at the November meeting by Loren W. Beebe, Ingersoll-Rand Co., Boston. Common causes of wasted air come from leaks in the system and inefficient design of tools of compressed air systems. —*F. S. Holway*

Metropolitan Chapter

Casting Defects Due to Sand

■ Silica sand is not the best possible molding refractory, George F. Watson, American Brake Shoe Co., Mahwah, N. J., told foundrymen at the October meeting.

Its limitations were listed as: possibility of being just refractory enough; has relatively high expansion and may have a fairly high chemical reactivity with other oxides to form slag. In addition, it frequently is used with binders which promote mold-metal reactions.

Clayballs can be particularly troublesome in fine natural sands with the sticky iron oxide type of clay. Once these balls which are high in moisture and clay, form they must be removed by screening. An aid to their prevention is use of a sand low in natural clay and a good grade of bonding clay with moisture and fines low.

Expansion defects such as rat-tailing, buckling, veining and scabbing result from the natural expansion of silica. A low density sand whether achieved by soft ramming, poor flowability or sand additions, is less likely to promote these defects. High green strength sands will not produce scabs. —*C. H. Fetzer*

Philadelphia Presents Annual Foundry Course

■ Philadelphia Chapter's third elementary foundry course is being presented at the Murrell Dobbins Vocational-Technical School, Philadelphia.

The 15-week course which started Nov. 17 is designed to give practical knowledge of sand casting to those not directly connected with coremaking or molding. Those attending include patternmakers, machinists, engineers, draftsmen, designers, casting buyers, inspectors, shop teachers, salesmen and technicians. Included in the course are green sand molding with various types of patterns both on the bench and floor, coremaking and melting, pouring and handling of metal.

Plant visitations, demonstrations and films will supplement lectures.

The course is sponsored by the Philadelphia Chapter and directed by the education committee headed by Chairman E. X. Enderlein, H. G. Enderlein Co., Philadelphia and Vice-Chairman John M. Schraeder, Olney Foundry Div., Link-Belt Co.

Eastern New York Chapter

Cutting Blast Cleaning Costs

■ How to obtain maximum benefits from blast cleaning with minimum expenditures were outlined at the October meeting by George O. Pfaff, Wheelabrator Corp., Mishawaka, Ind. Three types of shot were described—chilled, malleable and steel. —*Leonard C. Johnson*

chapter news

Southern California members at the October meeting heard **A. B. DeRoss,** Kaiser Aluminum Chemical Sales, Chicago (left) discuss the new alloy X-237. On right is Chapter Chairman **Otto H. Rosentreter,** Otto H. Rosentreter Co., South Gate, Calif.—*E. K. Appleman*

Texas Chapter

Conducts Panel Discussion

■ Non-ferrous melting practice was discussed at the October meeting by a panel of Texas foundrymen. National Director Jake Dee, Dee Brass Foundry, Houston, served as moderator. Panelists were: Jack Maenza, Dee Brass Foundry; John Bird, American Brass Foundry, Ft. Worth; King Tetley of Nibco of Texas, Nacogdoches; Robert Colton, Federated Metals Co., Houston.

Colton discussed why non-ferrous metals can be gassed during melting and pouring operations, stressing that gases are caused by the disassociation of water into hydrogen and oxygen. Oxygen takes the form of an oxide or oxides while the dissolved hydrogen is the source of gas pockets found in the castings, the hydrogen being thrown out of solution as the metal cools in the mold, especially during freezing. Each of the panel members described melting and degassing practices in their shops.

Moderator Dee brought up the subject of shrinkage. Colton described the mechanism of shrinkage calling attention to two types in non-ferrous alloys. Manganese and aluminum bronzes develop shrinkage which occurs in alloys having a narrow temperature range. Tin bronzes produce a different shrinkage since they have a wide temperature freezing range so that with the growth of crystalline structure small pools of liquid metal are isolated. Since these isolated pools cannot be fed, tiny inter-crystalline shrink voids are formed. Methods of avoiding shrinkage advanced by the panel included gating, risering, external chills and insulated risers and proper pouring temperature.

Turbulence was the third topic. Methods for avoiding turbulence used by the panel included bottom gating, changing the direction of flow two or three times in the runner to throw off dross, and the use of chokes to control the velocity of flow. Other suggestions were the use of tapered down sprues kept full by strainer cores or other means of choking to prevent the entrainment of air and the use of a well at the sprue bottom.—*Harold H. Judson*

Texas foundrymen serving on panel at October meeting of **Texas** Chapter; National Director **Jake Dee, Jake Maenza, John Bird, King Tetley** and **Robert Colton.**

Eastern Canada Chapter

Conducts Top Management Night

■ Estimating and analysis of casting costs were explained to 120 foundrymen at the November meeting. Speakers at the Top Management Night were H. Kreutz, Dominion Engineering Works, Ltd., Lachine, Que. and R. Stott, Canadian Steel Foundries, Ltd., Montreal, Que.—*R. B. Hill*

Wisconsin Chapter

Conducts Division Meetings

■ Five simultaneous sessions devoted to gray iron, steel, malleable, nonferrous and pattern were conducted in November at the Schroeder Hotel. Division speakers were gray iron, Edward Price; steel, George DiSylvestro; malleable, Willard Adams; non-ferrous, William L. Rudin; pattern, J. E. Mathias.

Members of the chapter's five technical divisions served as chairmen and co-chairmen of the sessions.

W. L. Rudin, Elesco Smelting Co., Chicago (right) talked on *Non-Ferrous Casting Defects —Causes and Remedies.* **H. W. Zimbars** is with Waukesha Foundry Co.

Edward Price, Dayton Malleable Iron Co., Dayton, Ohio (left) discussed *Efficiency in Cleaning Room Operations.* **J. G. Weber,** Walter Gerlinger, Inc., was technical chairman.

Willard Adams, Eastern Clay Products Dept., International Minerals & Chemical Co., Skokie, Ill., discussed *Green Sand Molding.* **Don Feather** is with Appleton Electric Co.

J. E. Mathias, Accurate Match Plate Co., Chicago (left) talked on *Core Boxes from Core Plugs.* Seated on right is **Erwin Czerwinski,** Nelson Pattern Co.—*Bob DeBroux*

George DiSylvestro, American Colloid Co., Skokie, Ill. (right) spoke on *Acid Ladle Practice.* **Jack Baumgartner,** Crucible Steel Casting Corp., served as technical chairman.

Northwestern Pennsylvania Chapter

Automated Pouring, Molding

■ An illustrated lecture on *The Buhrer Molding and Pouring Method* was presented at the October meeting by Alex H. Homberger, International Automation Corp., Ann Arbor, Mich. Sequences shown included compacting the mold, stripping, flask design, subdivided pattern plate, transfer and closing methods, design of top runner systems, pouring and cooling molds, shakeout return, conveyor systems and sand handling and capacity. Vice-Chairman William Eccles presided.—*H. L. Buchanan*

Tennessee Chapter

Makes Tour of Sand Plants

■ Working of silica sand deposits, processing and testing were observed by 22 members of the Tennessee Chapter in October. Three plants of the Hardy Sand Co. were toured at Camdem, Tenn., and a TVA steam electric generating plant at Johnsville, Tenn.

Foundrymen witnessed the preparation of a natural bonded molding sand; processing of various grades of silica sand including washing, drying, selection of grain size and blending for intermediate grades; and the working of an alluvial sand deposit.

Guiding the tour were Tom H. Hardy, Harry P. Hardy and J. T. Wakeland of Hardy Sand Co.—*H. G. Nelson*

Western New York

Growth of Self-Curing Binders

■ Perfection of organic self hardners to the point of elimination of baking was forecast by O. J. Myers, Reichhold Chemicals, Inc., White Plains, N. Y., at the November meeting.

Efficient use of self hardeners calls for fast set-up time for all jobs. Suggested steps:

- Determine time to fill, tuck and vibrate box.
- Add 10 per cent as safety factor.
- Determine set-up time of sand using a specific percentage of accelerator.
- Determine sand necessary to fill box—add 10 per cent.
- Place sand in muller with normal binder and sufficient accelerator to give full time plus 15 minutes.—*Don Kreuder*

Members of **Tennessee Chapter** watching discharge of wet silica sand during fall tour.

Current legislation and its impact on foundries was presented at the **Tennessee Chapter** October meeting by **H. J. Weber,** AFS Director of Safety, Hygiene and Air Pollution (third from left). Also attending was AFS National Director **Karl L. Landgrebe,** Wheland Corp., Chattanooga, Tenn., on Weber's left. Chapter officers from Chattanooga are: Treasurer James W. Richie, Foundry Pattern Service; Secretary Frank M. Robbins, Jr., Robbins & Bohr; Chairman W. L. Austin, U.S. Pipe & Foundry Co.; Director James E. Abshire, Jr., Porter Warner Industries, Inc.—*H. G. Nelson*

Philadelphia Chapter chairman (1957-58) **H. C. Winte,** Florence Pipe & Foundry Co., Florence, N. J., (left) receives chapter's gift of luggage from former Chapter Chairman **John M. Robb,** Pennsylvania Foundry Supply & Sand Co., Philadelphia.—*Leo Houser and E. C. Klank*

Philadelphia Chapter in October conducted "William B. Coleman Night." **Dr. James Creese,** Drexel Institute of Technology, Philadelphia (center) spoke on *The Common Ground of Industry and Education.* On left is Chapter Chairman **T. R. Walker, Jr.,** U. S. Pipe & Foundry Co., Burlington, N. J. Technical chairman is **W. W. Money, Jr.,** Olney Foundry, Phildelphia.

Moldable exothermic materials were explained at the November meeting of the **Pittsburgh Chapter** by **John Gothridge,** Foundry Services, Inc., New York. August Rossetti, McConway & Torley Corp., told of their experience with exothermic materials.—*Walter Napp*

chapter news

Saginaw Valley held ferrous, steel and permanent mold and die casting sessions at November meeting. Left to right are: Chapter Chairman **Arthur H. Karpicke,** AFS Vice-President **C. E. Nelson;** ferrous speaker **Howard H. Wilder;** Chapter Secretary **George R. Frye;** Chapter Vice-Chairman **Ormond Requadt;** Chapter Treasurer **Frank Buike.**—*John R. Fraker*

Saginaw Valley's November meeting was attended by AFS Vice-President C. E. Nelson and Technical Council Chairman Howard H. Wilder. Left to right are Chapter Director **Glenn Stuart;** steel speaker **H. F. Bishop;** technical chairman **Samuel Fair;** permanent mold and die casting speaker **John Atols** and technical chairman **Nicholas Sheptak.**

Michiana Chapter

Hears Two Speakers

■ Simultaneous ferrous and non-ferrous sessions were held at the November meeting. Ray Cochran, R. Lavin & Sons, Chicago, spoke on *Causes and Corrections of Casting Defects* emphasizing preventative measures.

T. E. Barlow, Eastern Clay Products Div., International Mineral & Chemicals Corp., Chicago, outlined *Ills and Cures for Synthetic Sand Users* pointing good and bad mixes is between good and bad mixes is that of attention to details.—*Walt Ostrowski*

Self-curing binders were discussed at **Western New York** November meeting by **O. Jay Myers,** Reichhold Chemicals, Inc., White Plains, N.Y. (right) shown with Chapter Chairman **L. B. Polen,** Allegheny Ludlum Steel Corp., Buffalo, N.Y.—*Walter Napp*

Attending November **Western New York Chapter** meeting were chapter directors **R. E. Lumley,** Buffalo Pipe & Foundry Corp., Buffalo, N.Y. and **E. J. O'Connell,** American Radiator & Standard Sanitary Corp., Buffalo, N.Y. On right is Chapter Vice-Chairman **A. J. Heysel,** E. J. Woodison Co., Buffalo, N.Y.

Eastern New York Chapter

Buhrer Automated Method

■ An illustrated lecture on the Buhrer automated molding and pouring method was presented at the November meeting by Alex H. Homberger, International Automation Corp., Ann Arbor, Mich.

Four principle methods of molding were covered—high pressure jolting, high frequency vibration, static or squeezing and dynamic blowing. Homberger also explained the jolting machine operation, principles of striking off and damping results and the sand cooler.—*Leonard C. Johnson*

Tri-State Board of Directors meeting held in November at Bartlesville, Okla. Director **Russell Emig,** National Cylinder Gas Co.; Director **T. H. Lahmeyer,** Lahmeyer Pattern Works; **Hilbert Hibbs,** Oklahoma Steel Castings Co.; Director **Edward O'Brien,** Oklahoma Steel Castings Co.; Secretary **Jackson A. Dean,** Nelson Electric Mfg. Co.; Director **J. L. Potillo, Jr.,** Jake's Foundry, Inc.; Membership Chairman **Frank M. Scaggs,** Oklahoma Steel Castings Co.; Chairman **Emmett F. Hines,** Nemco Foundry Co.; Treasurer **Harry J. Ferlin,** Tulsa Pattern & Mfg. Co.; Vice-Chairman **William Pitts,** Oklahoma Steel Castings Co.—*Leslie O'Brien*

Tri-State Chapter members and speaker at November meeting. Left to right: Director **Jules J. Henry,** Missouri Steel Casting Co., Joplin, Mo.; Chairman **Emmett F. Hines,** Nemco Foundry Co., Tulsa, Okla.; **Dale L. Hall,** Oklahoma Steel Castings Co., Tulsa, Okla.; speaker **Ralph C. Brown;** Secretary **Jackson A. Dean,** Nelson Electric Mfg. Co., Tulsa, Okla.; Vice-Chairman **William Pitts,** Oklahoma Steel Castings Co., Tulsa, Okla.

Central New York Chapter

Casting Economics, Design

■ Principles of casting economics and design were outlined to 310 foundrymen and guests—largest in the chapter's history—in November by S. C. Massari, AFS Technical Director.

Attending were representatives from 54 companies in the chapter area and the Technology Club of Syracuse, N. Y. Chapter Chairman Ralph J. Denton, Denton Refractory Service Corp., Syracuse, N. Y., presided. Kenneth Dignes, Oberdorfer Foundries, Inc., Syracuse, N. Y., acted as technical chairman.

Carrier Corp., Syracuse, N. Y., acted as host. The technical meeting was held in the Carrier auditorium and dinner in the company dining hall. Foundrymen also toured the Carrier plant.

Liason is the key to economical and soundly engineered castings, said Massari. This liason must be maintained between foundry and the customer from the development of the initial design to the selection of pattern equipment, metal and ultimate dimensional requirements.

Topics covered included advantages of castings, casting design, selection and construction of pattern equipment, selection of the metal and new product development.

C. V. Fenn, Carrier Corp., welcomes foundrymen to Carrier Corp. Technical meetings were held in company auditorium and dinner in the cafeteria.

Record turnout for the Central **New York Chapter** was registered by **Marie Taylor** and **Jimmie Sue Fisk,** Carrier Corp. **Robert R. Stanton** and **Wendell F. Erwin** watch the watching guests.

Chesapeake Chapter

Conducts 3-day Show

■ Foundrymen from the Chesapeake Bay area attended the Chesapeake Chapter's sand school conducted Oct. 27-29 by Victor Rowell, Harry W. Dietert Co., Detroit. Classes were conducted at the Mergenthaler Vocational Technical High School. Participating were men from Pennsylvania, New Jersey as well as Washington, D. C. and Baltimore.—*D. Roemer.*

Fundamentals of casting design were explained to St. Louis members at the October meeting by **R. L. Gilmore,** Superior Steel & Malleable Castings Co., Benton Harbor, Mich. Technical Chairman **Ted Padkins,** Scullin Steel Co., St. Louis (right) congratulates Gilmore.

Birmingham Chapter

Hears Talk on Coreroom

■ Most coreroom problems can be cured by following basic principles, Tom C. Alford, Tri-State Sand Co., Chattanooga, Tenn., told the chapter at its October meeting.

Control of the following was recommended: selection of supervision, selection of raw materials, good mixing equipment, good maintenance program and accurate measuring.—*W. A. Quenelle*

Die casting and permanent mold advances were explained to the **Toledo Chapter** at its October meeting by **Donald L. Colwell,** Apex Smelting Co., Cleveland. Left to right are Chapter Vice-Chairman **Thaddeus Giszczak,** Central Foundry Div., GMC, Defiance, Ohio; Technical Chairman **George F. Hodgson,** Doehler-Jarvis Div., National Lead Co., Toledo, Ohio; speaker **Colwell;** Chapter Chairman **R. E. Bossert,** Maumee Malleable Casting Co., Toledo, Ohio.—*C. M. Hannaford*

Head table at **Central New York** Chapter's November meeting attended by 300. Left to right: **R. Stanton** and **T. Hughes,** Carrier Corp.; **K. Digney,** Oberdorfer Foundries, Inc.; **B. R. Artz,** Pangborn Corp.; AFS Technical Director **S. C. Massari;** Chapter Chairman **Ralph J. Denton; C .V. Fenn,** Carrier Corp.; AFS National Director **W. D. Dunn; Edward Fiesinger,** Crouse-Hinds Corp.—*C. W. Diehl*

chapter news

Applying the CO_2 process to iron, steel and non-ferrous castings was discussed at the October meeting of the **Twin City** Chapter. Introducing the panel is Chapter Vice-Chairman **Carter DeLaittre,** Minneapolis Electric Steel Castings Co., Minneapolis. Also standing is moderator **Carl W. Sundberg,** Minneapolis Electric Steel Co. Seated are: **Melvin P. Schroeder,** Prospect Foundry Co., Minneapolis; **John Wallfred,** Minneapolis Electric Steel Castings Co.; **Lyle Perkins** Northern Malleable Iron Co., St. Paul, Minn.—*J. David Johnson*

Corrections and causes of casting defects and use of synthetic binders were discussed at the **Michiana** November meeting. Left to right: **Fred Riddell,** H. Kramer & Co., Chicago; speaker **T. E. Barlow,** Eastern Clay Products Div., International Mineral & Chemicals Corp., Chicago; Chapter Chairman **Phil Semler,** Auto Specialties Mfg. Co., St. Joseph, Mich.; speaker **Ray Cochran,** R. Lavin & Sons, Inc., Chicago; Technical Chairman **Robert Hull,** Casting Service Corp., LaPorte, Ind.—*Walt Ostrowski*

Attending Eastern Canada Chapter's Top Management Night were front row: Chapter Chairman **M. Reading,** Foundry Services, Ltd.; AFS National Director **J. King,** Archer-Daniels-Midland Co. (Canada), Ltd.; speaker **R. Stott,** Canadian Steel Foundries, Ltd.; **A. Lewis, Crestweld** Mfg., Ltd.; **J. Moore,** Canadian Bronze, Ltd. Back row: **J. Hunt,** Canadian Bronze, Ltd.; **T. Niven,** Canadian Steel Foundries, Ltd.; **G. D. Turnbull,** Canada Iron Foundries, Ltd.; speaker **H. Kreutz,** Dominion Engineering Works, Ltd.; Chapter Secretary **L. Myrand,** Montreal Foundry, Ltd.

Tri-State Chapter

Modern Patternmaking

■ Cooperation between patternmakers, purchasing departments and operating departments is essential to produce patterns of suitable quality to cover anticipated production, Ralph C. Brown, Ramsey Winch Mfg. Co., Tulsa, Okla., explained at the November meeting.

Brown suggested the following letter system for standardization in classifying pattern equipment:

A—Very high production (shell mold and equivalent).

B—High production (green sand or CO2).

C—Moderate production (aluminum or metal faced).

D—Low production (hardwood equipment).

E—Samples only (pine pattern). —*Leslie O'Brien*

Methods of blast cleaning, descaling and shot peening of metal surfaces were explained at the November meeting of the **Central Ohio** Chapter by Robert G. Halls, Pangborn Corp. Slides were shown of equipment in use.—*Joseph A. Riley, Jr.*

D. James, Urick Foundry Co., Erie, Pa., (left) shown with three new Northwestern Pennsylvania Chapter members from National Steel & Malleable Corp., Sharon, Pa. Left to right: **J. W. Davis, W. McIntyre** and **E. O. Spahr.**—*Walter Napp*

AFS Pattern Division Chairman **O. C. Bueg,** Arrow Pattern & Engineering Co., Erie, Pa., addressing **Pittsburgh Chapter** on epoxy patterns and core boxes.

Northwestern Pennsylvania Chapter Vice-Chairman **William E. Eccles,** Cooper-Bessemer Corp., Grove City, Pa., congratulates October speaker **Alex H. Homberger,** International Automation Corp., Ann Arbor, Mich. Homberger discussed the Burher automated molding and pouring method.—*Walter V. Napp*

James Reedy, Hill & Griffith Co., address November meeting of **Texas Chapter** on coreroom practice. Effect of grain size and distribution in core sands and varying percentage of moisture and binders were illustrated.

Reporter Napp

Walter V. Napp, Milwaukee Chaplet & Mfg. Co., Pittsburgh, is the only AFS reporter covering three chapters. Napp, who for eight years was photographer for Wisconsin Chapter, now regularly covers meetings of the **Pittsburgh, Northwestern Pennsylvania** and **Western New York** chapters.

Pittsburgh Chapter officers: President **I. W. Sharp,** American Steel Foundries, Verona, Pa.; Vice-President **James D. Wilson,** Bronze Die Casting Co., Pittsburgh, Pa.; Secretary-Treasurer **E. P. Buchanan,** Pittsburgh Coke & Iron Co., Pittsburgh, Pa.—*Walter Napp*

Attending **Texas Chapter** November meeting to hear speaker **James Reedy** (left) were: former AFS Director Robert Trimble, National Director **Jake Dee; Fred Jacobs,** Texas Foundries, Inc.; **Ross Williams,** East Texas Steel Castings Co.; **Charles McGrail,** Alamo Iron Works; **Edwin Pollard,** Western Foundry Co.—*Harold H. Judson*

Chicago Names Show Chairmen

■ Chairmen for convention committees have been appointed by the Chicago Chapter, host chapter to the AFS Annual Convention to be held April 13-17 at the Sherman and Morrison Hotels, Chicago.

Activities will be directed by the general convention committee headed by C. V. Nass, Beardsley & Piper Div., Pettibone Mulliken Corp. Other members are D. G. Schmidt, H. Kramer & Co.; W. O. McFatridge, International Harvester Co.; R. P. Schauss, Werner G. Smith, Inc.; and J. T. Moore, Wells Mfg. Co.

Members of the general convention committee are former chairmen of the Chicago Chapter.

Convention committees:

Ladies Committee—chairman, J. H. Owen, Harbison, Walker Refractories Co.; co-chairmen, C. K. Faunt, Faunt Foundry Co. and W. W. Moore, Burnside Steel Foundry Co.

Banquet Committee—chairmen, R. L. Doelman, Miller & Co.; co-chairmen, R. C. Johnston, Hickman, Williams & Co.; Harold Johnson, Wells Mfg. Co.

Publicity Committee — chairman, W. D. McMillan, International Harvester Co.; co-chairman, H. L. Overman, Whiting Corp.

Plant Visitations—chairman, James Thomson, retired; co-chairman H. A. Young, Crane Co.

Reception Committee—chairman, J. C. Gore, retired.

Shop Course Committee — chairman, John Rassenfoss, American Steel Foundry Co.; co-chairman, L. H. Rudesill.

Time and motion study applications for the foundry were discussed at the November meeting of the **Cincinnati Chapter** by **Jeff A. Westover,** Westover Corp., Milwaukee, Wis. Recommendations were made on how to develop standards for increased production.—*J. D. Claffey*

afs chapter meetings

JANUARY

Birmingham District . . Jan. 9 . . Thomas Jefferson Hotel, Birmingham, Ala. . . J. S. Vanick, International Nickel Co. *"The Casting–Iron, Steel, Brass." Management Night.*

British Columbia . . Jan. 16 . . Leon's, Vancouver, B. C. . . C. A. Sanders, American Colloid Co., *"Is Your Sand Scrap Showing?"*

Canton District . . Jan. 8 . . Elks Club, Barberton, Ohio . . C. W. Gilchrist, Cooper-Bessemer Corp., *"Ductile Iron."*

Central Illinois . . Jan. 5 . . American Legion Hall, Peoria, Ill. . . J. E. Stock, John Deere Waterloo Tractor Works, *"Shell Cores."*

Central Indiana . . Jan. 5 . . Athenaeum, Indianapolis . . *Panel*: K. A. Miericke, Baroid Div., National Lead Co.; E. E. Wene, Link-Belt Co.; C. M. Eberhardt, Central Foundry Div., GMC; J. D. Sickmann, Swayne, Robinson Co.; *Moderator*: D. Lunsford, Perfect Circle Corp., *"What's New in Foundry Sands." National Officers' Night.*

Central Michigan . . Jan. 21 . . Hart Hotel, Battle Creek, Mich. . . H. J. Weber, AFS, *"Some Experiences with Wasting Money in Foundry Operations."*

Central New York . . Jan. 9 . . Drumlins Country Club, Syracuse, N. Y.

Central Ohio . . Jan. 24 . . Lincoln Lodge, Columbus, Ohio . . *Annual Party.*

Chesapeake . . Jan. 10 . . American Legion Hall, Parkville, Md. . . *Annual Oyster Roast . .* Jan. 30 . . Engineers' Club, Baltimore, Md. . . L. Palmer, American Metaseal Corp., *"Castings Impregnation."*

Chicago . . Jan. 5 . . Chicago Bar Association, Chicago . . J. B. Caine, Consultant, *"Casting Design."*

Cincinnati District . . Jan. 12 . . Alms Hotel, Cincinnati . . *Ferrous Group*: J. F. Wallace, Case Institute of Technology, *"Gating of Gray Iron Castings"*; *Non-Ferrous Group*: D. L. LaVelle, Federated Metals Div., American Smelting & Refining Co., *"Care & Feeding of Aluminum Castings."*

Connecticut . . Jan. 9 . . Waverly Inn, Cheshire, Conn. . . *Holiday Party . .* **Jan. 27 . .** Waverly Inn, Cheshire, Conn. . . *Round Table.*

Corn Belt . . Jan. 9 . . Marchio's Steak House, Omaha, Neb. . . H. H. Wilder, Vanadium Corp., *"Gray Iron Cupola Practices."*

Detroit . . Jan. 15 . . Wolverine Hotel, Detroit . . W. C. Capehart, Monsanto Chemical Co., *"Advancements in Resin Coated Processes."*

Eastern Canada . . Jan. 9 . . Sheraton Mt. Royal Hotel, Montreal, Que. . . R. L. McIlvaine, National Engineering Co., *"Foundry Mechanization."*

Eastern New York . . Jan. 20 . . Panetta's Restaurant, Menands, N.Y. . . A. Steck, Metallurgical Associates, *"New Processes in the Foundry."*

Metropolitan . . Jan. 5 . . Essex House, Newark, N. J. . . H. J. Heine, Malleable Founders' Society, *"Casting Quality & Properties as Influenced by Design."*

Mexico . . Jan. 26 . . Ave. Chapultepec 414, Mexico D.F., Mexico . . *Round Table on "Manufacture of High Manganese Austenitic Steel Castings."*

Michiana . . Jan. 12 . . Club Normandy, Mishawaka, Ind. . . *Non-Ferrous Group*: F. L. Riddell, H. Kramer & Co., *"Make Higher Quality Copper Base Castings"; Ferrous Group*: G. O. Pfaff, Abrasive Div., Wheelabrator Corp., *"Reducing Blast Cleaning Costs."*

Mid-South . . Jan. 9 . . Claridge Hotel, Memphis, Tenn. . . A. E. Tull, Air Reduction Sales Co., *"The Calcium Carbide Injection Process."*

New England . . Jan. 14 . . University Club, Boston . . . J. T. Coggin, General Electric Co. Elmira Foundry, *"Recent Observations of Foundry Operations in Europe."*

Northeastern Ohio . . Jan. 8 . . Tudor Arms Hotel, Cleveland . . J. A. Babcock, Pickands Mather & Co., *"Taconite."*

Northern California . . Jan. 12 . . Spenger's, Berkeley, Calif. . . C. A. Sanders, American Colloid Co, *"What Sand for What Type of Casting."*

Northern Illinois & Southern Wisconsin . . Jan. 13 . . Beloit Country Club, Beloit, Wis. . . *Sand Panel, "Sand Defects, Causes and Corrections."*

Northwestern Pennsylvania . . Jan. 26 . . Amity Inn, Erie, Pa. . . R. W. Zillman, Pittsburgh Steel Foundry Corp., *"CO_2 Process in Steel Foundry Practice."*

Ontario . . Jan. 23 . . Royal York Hotel, Toronto, Ont. . . L. L. Gill, Harbison-Walker Refractories Co., *"Modern Refractories." Student Night.*

Oregon . . Jan. 14 . . Heathman Hotel, Portland, Ore. . . C. A. Sanders, American Colloid Co., *"Sand Technology."*

Philadelphia . . Jan. 9 . . Engineers' Club, Philadelphia . . R. B. Fischer, Ingersoll-Rand Co., *"Factors That Influence Gating & Risering."*

Piedmont . . Jan. 9. . . Holiday Inn Motel, Greenville, S. C. . . C. V. Nass, Beardsley & Piper Div., Pettibone Mulliken Corp., *"Mechanism for the Small Foundry."*

Pittsburgh . . Jan. 19 . . Webster Hall Hotel, Pittsburgh, Pa. . . R. A. Clark, Electro Metallurgical Co., Div. of Union Carbide Corp., *"Metallurgy of Cast Iron."*

Quad City . . Jan. 19 . . LeClair Hotel, Moline, Ill. . . J. R. Nieman, Shell Process, Inc., *"Jobbing with Shell Cores & Molds."*

Rochester . . Jan. 6 . . Manger Hotel, Rochester, N. Y. . . J. F. Roth, Cleveland Standard Pattern Works, *"The Patternmaker's Application of Plastic in Industry."*

Saginaw Valley . . Jan. 8 . . Fischer's Hotel, Frankenmuth, Mich. . . H. J. Weber, AFS, *"Control of Foundry Noise."*

St. Louis District . . Jan. 8 . . Edmond's, St. Louis . . R. A. Witschey, A. P. Green Fire Brick Co., *"Fundamentals of Refractories."*

Southern California . . Jan. 9 . . Rodger Young Auditorium, Los Angeles . . C. A. Sanders, American Colloid Co., *"Casting Finish, Precision & Tolerance."*

Tennessee . . Jan. 23 . . Patten Hotel, Chattanooga, Tenn. . . G. E. Sutton, Jr., General Electric Co., *"Productive Maintenance–1959."*

Texas . . Jan. 16 . . Baker Hotel, Dallas, Texas . . A. H. Zrimsek, Magnet Cove Barium Corp., *"Foundry Sands & Binders."*

Timberline . . Jan. 12 . . Oxford Hotel, Denver . . Z. Madacey, Beardsley & Piper Div., Pettibone Mulliken Corp., *"Core Blow Applications."*

Toledo . . Jan. 7 . . Heatherdowns Country Club, Toledo, Ohio . . W. A. Mader, Oberdorfer Foundries, Inc., *"CO_2 Experience in Non-Ferrous Foundry."*

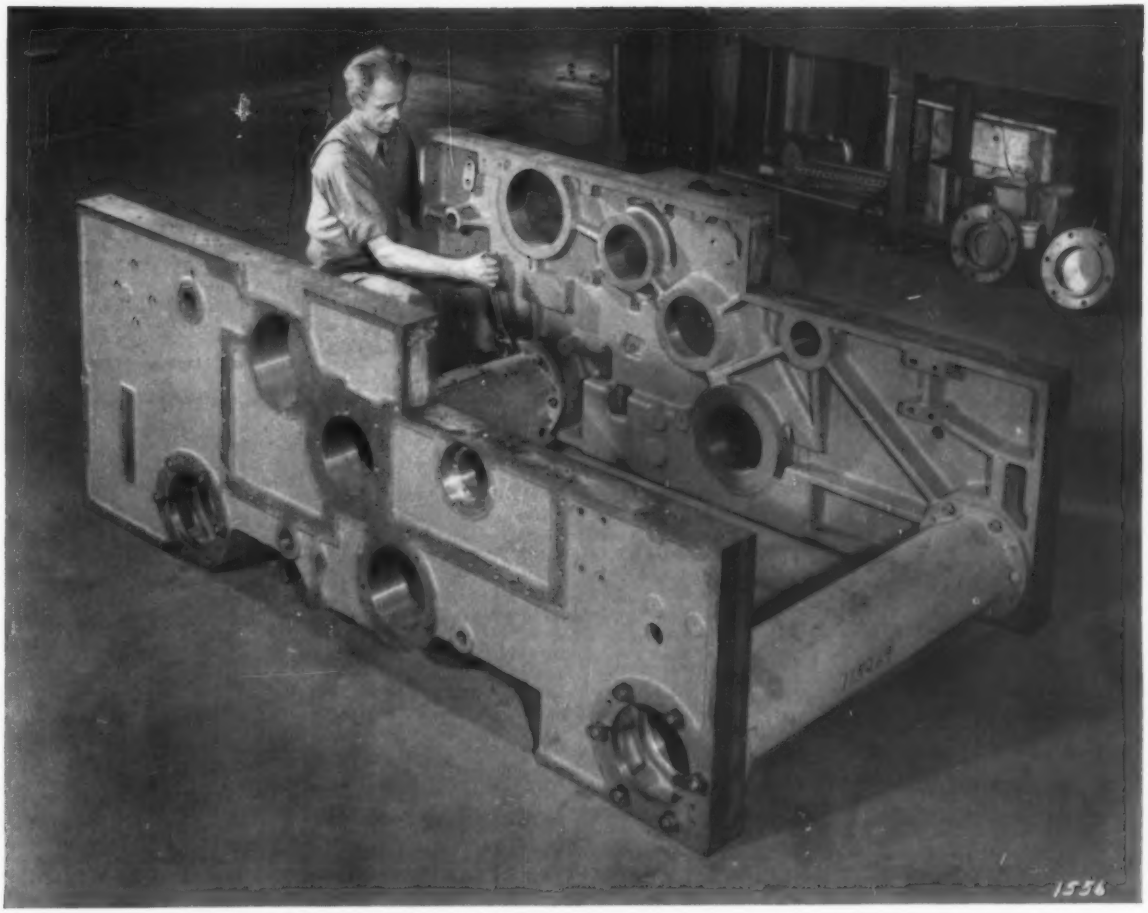
Tri-State . . Jan. 9 . . Tulsa, Okla. . . E. J. Boywid, International Harvester Co., *"Safety & Hygiene in the Foundry."*

Twin City . . Jan. 13 . . Jax Restaurant, Minneapolis . . H. J. Weber, AFS, *Noise –A New Problem Confronting Foundries."*

Utah . . Jan. 19 . . Grandview Cafe, Provo, Utah . C. A. Sanders, American Colloid Co., *"Does this Scrap Occur in Your Foundry."*

Washington . . Jan. 15 . . Engineers' Club, Seattle . . C. A. Sanders, Ameri-

Continued on page 149



1300 pound cast frame for large high speed bag-making machine. L. Brayton Foundry Co. uses a 1% nickel cast iron for frames to assure accurate alignment of shafts and cross members during assembly by St. Regis Paper Company, East Providence.

How nickel irons help you maintain control of large, complex castings

One of the easiest ways to obtain dimensional stability in a big, intricate casting is to use a nickel cast iron.

Take the matched frame members shown above, for example.

You'll see the problem right away. Unless cored holes and to-be-machined surfaces line up almost perfectly . . . up go machining costs.

Now notice the heavy bosses and ribs. And take note that the supporting web is ½-inch thin. You would expect some chill in this web and a tendency to warp. And you might forecast a costly stress relief or expensive set-up time in machining operations.

L. Brayton Foundry got around all this quite easily. By using a nickel cast iron mix, they were able to deliver these frames "as cast" and meet all requirements for dimensional accuracy.

Nickel irons give you more control over chill...help keep warping stresses low

Nickel cast irons show less tendency to chill. With these irons, structure is more uniform. Build-up of internal warping stresses in large, complex castings is not as high.

What's more, selection of the right grade of nickel iron gives you improved control over structure, and hence, machinability, wear resistance, strength and other properties desired by you and your customers.

Pass on to your customers the benefits of nickel cast irons

Next time you have an order coming up for a large, complex casting, look into the economics of nickel cast irons. You may be able (1) to reduce your own costs or (2) to provide your customer with a much better casting.

Maybe you can do both. The way to find out is to contact Inco. Inco's engineering service can help you . . . on either a special foundry problem or to help convince a customer.

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67 Wall Street New York 5, N. Y.

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TRADE MARK

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Build an idea-file for improvement and profit. The post-free cards on the last page will bring more information . . .

for the asking

Shell core blower . . . illustrated on data sheet. Shell cores up to 10-in. diameter and 12-in. height claimed. *Harrison Machine Co.*
Circle No. 100, Page 155-156

Overhead sand . . . conveying and storage systems for molding, coremaking and other operations explained and pictured in brochure. *Jeffrey Mfg. Co.*
Circle No. 101, Page 155-156

Depressed center . . . abrasive wheels designed for weld grinding and general use described in brochure. *Simonds Abrasive Co.*
Circle No. 102, Page 155-156

Lift trucks . . . 2000-lb capacity, detailed in brochure. *Allis-Chalmers Mfg. Co.*
Circle No. 103, Page 155-156

Dust control . . . problems and how companies solve them are illustrated in 12-p brochure including selection, pricing and accessory information. *Flexaust Co., Div. Callahan Zinc-Lead Co.*
Circle No. 104, Page 155-156

Low pressure . . . compressors for heavy-duty industrial use featured in 8-p bulletin. *Joy Mfg. Co.*
Circle No. 105, Page 155-156

Tumbling media . . . for barrel finishing explained with job analysis, functions and case histories in bulletin. Circle number below. *Carborundum Co.*
Circle No. 106, Page 155-156

Ductile iron . . . alloys described and specifications listed in bulletin. *Vanadium Corp. of America.*
Circle No. 107, Page 155-156

Storage racks . . . featuring all-adjustable construction for either pallets or skids fully discussed in 16-p brochure. *Paltier Corp.*
Circle No. 108, Page 155-156

Welding . . . data book, 13 pp, offers guide for selecting proper welding alloy and welding procedure for specific jobs on every base metal. *Eutectic Welding Alloys Co. of Canada, Ltd.*
Circle No. 109, Page 155-156

Electric lift . . . trucks as well as gas-powered and hand operated materials handling trucks are covered in detail in company's case history publication including convenient mailing cards for information about specific items. *Lewis-Shepard Products, Inc.*
Circle No. 110, Page 155-156

Equipment leasing . . . methods described in brochure covering materials handling equipment. *Lewis-Shepard Products, Inc.*
Circle No. 111, Page 155-156

Power tools . . . and accessories for industrial use presented in catalog. *Delta Power Tool Div., Rockwell Mfg. Co.*
Circle No. 112, Page 155-156

Barrel machine . . . molded in one piece shown with specifications on data sheet. *Casalbi Co.*
Circle No. 113, Page 155-156

Hiring . . . of key executive for small plant discussed in brochure. *Small Business Administration.*
Circle No. 114, Page 155-156

Hydraulic cleaning . . . equipment discussed in detail, 8-p bulletin features jet models for heavy duty cleaning of walls, floors and equipment. *Sellers Injector Corp.*
Circle No. 115, Page 155-156

Ductile iron . . . mechanical and physical properties listed in 28-p brochure. Industrial applications pointed out. *International Nickel Co.*
Circle No. 116, Page 155-156

Shell core . . . machine presented in brochure pinpointing features and offering pictorial sequence of operation. *Dependable Pattern Works.*
Circle No. 117, Page 155-156

Vibratory feeders . . . conveyors, packers, screens and control systems featured in brochures available when you use circle number below on Reader Service card. *Syntron Co.*
Circle No. 118, Page 155-156

Shell molding . . . problems answered in brochure. Answers such questions as, "How to avoid casting fins in shell molding." *General Electric Co.*
Circle No. 119, Page 155-156

Belt idlers . . . application information and specifications presented in 12-p bulletin. *Joy Mfg. Co.*
Circle No. 120, Page 155-156

New specification . . . for low alloy steel covered arc-welding electrodes available when you circle number below on Reader Service card, page 7-8. *American Welding Society.*
Circle No. 121, Page 155-156

Gas welding . . . and cutting catalog describes torches, tips, regulators, accessories and specification sheets. *Harris Calorific Co.*
Circle No. 122, Page 155-156

Sand reclamation . . . discussed in regard to cost and advantages of equipment. Application to various types of foundry sand described. 16-p booklet. *Beardsley & Piper, Div. Pettibone Mulliken Corp.*
Circle No. 123, Page 155-156

Atlanta, Georgia . . . facts and figures booklet includes housing conditions, industry and many other topics of interest, 42 pp. *Atlanta Chamber of Commerce.*
Circle No. 124, Page 155-156

Power tools . . . catalog, 52 pp, includes recently announced belt sander and many other types. *Boice-Crane Co.*
Circle No. 125, Page 155-156

Blast cleaning . . . and dust control equipment presented in informative, 24-p brochure. *Pangborn Corp.*
Circle No. 126, Page 155-156

Four-wheeled truck . . . for heavy-duty manual handling of castings is described in data sheet. *Sterling National Industries, Inc.*
Circle No. 127, Page 155-156

Magnesium alloys . . . for use in production of ductile iron discussed in bulletin. Composition and use outlined. *Vanadium Corp of America.*
Circle No. 128, Page 155-156

Weather protected . . . electric motor data included in bulletin. *Louis Allis Co.*
Circle No. 129, Page 155-156

Welding supplies . . . and accessories catalog, 52 pp, includes fluxes, rods and protective clothing. *Air Reduction Sales Co.*
Circle No. 130, Page 155-156

get the inside story! read what manufacturers say about themselves! circle numbers on the card on the last page of this issue

Multiple compartment . . . barrel finishing machine for processing parts which cannot be finished in batch-type machines. Use circle number below for bulletin. *Wheelabrator Corp., Techline Div.*
Circle No. 131, Page 155-156

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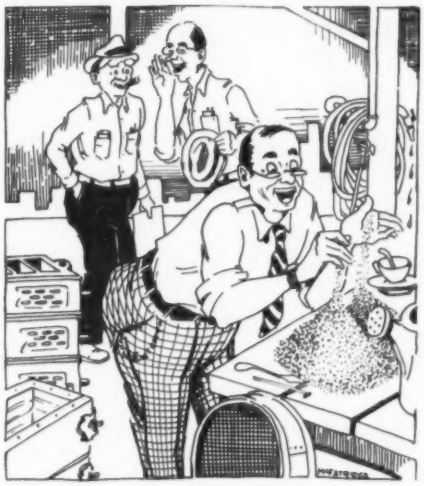
VOLCLAY BENTONITE

••••••••••NEWSLETTER No. 59••••••••••

REPORTING NEWS AND DEVELOPMENTS IN THE FOUNDRY USE OF BENTONITE

MOLDABILITY



"Since Volclay has been added to the molding sand, even the Superintendent likes to mold in it."

Moldability is measured by "feel" more than by instruments.

A mold must be made before a casting. A good mold produces a good casting, whereas a poor mold most generally produces a poor casting.

Some companies have found it advantageous to place inspectors at the molds, rather than at the inspection bench. This guarantees that no metal will be lost from a poor mold.

The bond added to a molding sand mixture generates the feel of the molding sand. VOLCLAY, western bentonite, offers a better "feel" to the molders than other bonds.

A molder is generally happy when a sand is working properly. If the molding sand is out of balance and the bond addition ignored, soon a production line may suffer because the molder is not doing his best. VOLCLAY requires small amounts of water for proper temper. Deformation and toughness of molding sand is always insured by a VOLCLAY addition. **No more than 5% by weight VOLCLAY with new unbonded sand is required.**

Obtaining the correct draw or lift with the sand mixture is most important. Production lines cannot wait if molding sand is not drawing correctly from the pattern. VOLCLAY bonded sand mixtures are more consistent in molding qualities, even with temperature variations in the sand mixture. **This is one of its strongest features!**

Write for

NL NO-15—"YOU MAY BE SURPRISED AT THIS!"

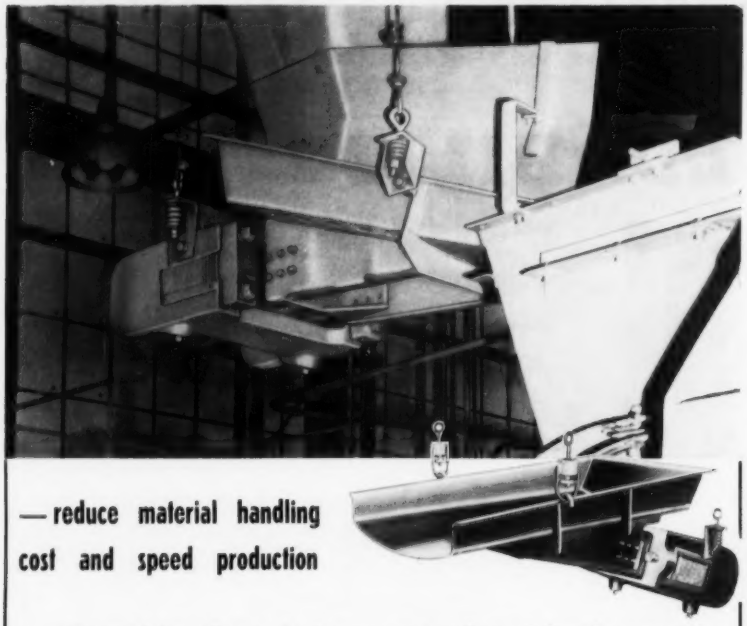
AMERICAN COLLOID COMPANY

SKOKIE, ILLINOIS • PRODUCERS OF VOLCLAY AND PANTHER CREEK BENTONITE

Circle No. 245, Page 155-156

SYNTRON Vibra-Flow

VIBRATORY FEEDERS



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SYNTRON Vibratory Feeders provide a smooth uniform flow of materials to belt conveyors, screens, ladle streams, molds and other equipment. Rate of flow is instantly adjustable over a wide range to meet operational requirements.

Constructed to withstand load impact and excessive wear by abrasion SYNTRON Feeders work on an electromagnetic principle that eliminates motors, gears, bearings and belts and assures long dependable service with low maintenance.

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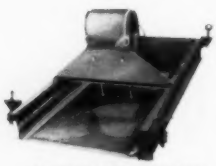

VIBRATING SCREENS

Circle No. 246, Page 155-156

for the asking

Continued from page 130

Aluminum welding . . . training manual designed for use with inert gas process available on request. *Kaiser Aluminum & Chemical Sales, Inc.*
Circle No. 132, Page 155-156

Aerosol spray . . . product history and industrial application discussed in 16-p booklet. *Crown Industrial Products Co.*
Circle No. 133, Page 155-156

Refractory . . . plastic material resists attack of molten metal and slag; applications outlined in brochure. *North American Refractories Co.*
Circle No. 134, Page 155-156

Foundry flasks . . . selection and maintenance detailed in booklet. *Sterling National Industries, Inc.*
Circle No. 135, Page 155-156

Barrel finishing . . . compounds designed for deburring, burnishing and descaling operations covered in brochure pointing up need for right combination of media, solution, speed and loading. *Oakite Products, Inc.*
Circle No. 136, Page 155-156

Flooring . . . heavy-duty and heat resistant, covered in bulletin. Describes 4-step laying process. *Walter Maguire Co.*
Circle No. 137, Page 155-156

Flux . . . for aluminum alloys discussed in 6-p bulletin. *Apex Smelting Co.*
Circle No. 138, Page 155-156

Casting resin . . . for surfacing and laminating. Bulletin deliniates physical properties and illustrates applications. *Rezolin, Inc.*
Circle No. 139, Page 155-156

Steel strapping . . . unit illustrated in data sheet reportedly combines tensioning and sealing, eliminating costly seals. *Inland Wire Products Co.*
Circle No. 140, Page 155-156

CO_2 shell molding . . . development reviewed. New process. Advantages of being non-inflammable and non-gas forming described. *Philadelphia Quartz Co.*
Circle No. 141, Page 155-156

Atomic Metallurgy . . . Shows how metallurgists produce and test specialized alloys necessary to the atomic energy program. Sixteen mm, 12-1/2 min, black and white, sound, free. *United States Atomic Energy Commission.*
Circle No. 142, Page 155-156

Time-zone map . . . depicting standard time zones of the United States and Canada offered. *Ohio Seamless Tube Div. Copperweld Steel Co.*
Circle No. 143, Page 155-156

Tooling compounds . . . explained, including coating, laminating, casting and high-temperature compounds. Circle number below for 6-p bulletin. *Houghton Laboratories, Inc.*
Circle No. 144, Page 155-156

Continued on page 134

CARBO-SIL® No. 4*

The Only Low-cost and Consistent Method of Adding Silicon Carbide in Your Cupola

A positive silicon source that:

- * Cuts Costs
- * Increases Machinability
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- * Controls Chill

CARBO-SIL No. 4, a silicon carbide addition for cast iron cupolas, comes in 10 and 15-pound units encased in steel containers.

BECAUSE CARBO-SIL No. 4 comes in steel containers, every crystal of the precrushed silicon carbide is *fully* protected until it reaches the significant melting zone of the cupola. Then it *completely* reacts and goes into solution.

CARBO-SIL No. 4 is competitively priced with silicon carbide in briquette form. You save money because there's no waste. If briquettes are made sturdy, they only partially dissolve and often are found in the drop. If made fragile, they break up prematurely and are partially blown out the stack.

There are 4½ pounds of available silicon (as silicon carbide) in the 10-pound unit and 6¾ pounds in the 15-pound unit. Each container adds almost a pound of steel to your charge at no extra cost.

Write for details.

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CARBO-SIL No. 4 is packed in palletized, waterproofed and top-strapped units for space-saving outdoor storage.

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Circle No. 247, Page 155-156

the SHAPE of things

safety, hygiene, air pollution

by HERBERT J. WEBER

A Rose By Any Other Name

(Ductile, nodular or spheroidal graphite iron)

Since November's column, "Does Ductile Iron Stink", I came across more information about the odor occurring when ductile iron is machined. As I wrote in November, the odor is that of phosphine and, to a lesser extent, of hydrogen sulphide.

Magnesium phosphide is formed by direct reaction of magnesium with phosphorus as follows:

magnesium + phosphorus = magnesium phosphide,

$(3\,Mg + 2\,P = Mg_3P_2)$

The elements necessary for the formation of magnesium phosphide are present and presumably the phosphide hydrolyses to form phosphine in the following way:

magnesium phosphide + moisture = magnesium hydroxide + phosphine

$(Mg_3P_2 + 6H_2O = 3Mg(OH)_2 + 2PH_3$

Bowker* in a paper presented to the British Industrial Medical Officers last July found the following atmospheric concentrations of phosphine during the machining of three kinds of iron:

TYPE OF IRON	PHOSPHINE — PARTS PER MILLION ½ in. from cutting tool	8 in. from cutting tool
Spheroidal graphite	6.0	0.8
Gray cast	0.7	0.2
Meehanite	0.8	not detected

AVERAGE OF THREE DETERMINATIONS

Thus at a short distance from the cutting tool the concentration of phosphine decreases approximately eight fold. Bowker stated, "At further distances (more than 8 in.) none could be detected. I would emphasize that they (measurements) were obtained under experimental conditions. For various reasons we were not able to make the measurements in the machine shop itself".

However, the analytical method used by Bowker leads one to suspect its accuracy on samples in the minute amounts involved. There is quite a difference between a sensitive method and an accurate one. Here is Bowker's method:

"Air was drawn from a point at a measured distance from the cutting tool through a filter packed with cotton wool to remove dust. It was then passed through a bubbler containing lead acetate solution to remove traces of H_2S. The air was then passed through a second bubbler containing a 0.01N silver nitrate solution. The phosphine reacts with the silver nitrate solution in the following way:

$4H_2O + 8\,AgNO_3 + PH_3 = 8\,Ag + H_3PO_4 + 8\,HNO_3$

The metallic silver precipitated was filtered off, washed and dissolved in nitric acid. The silver nitrate solution was then titrated with N/40 potassium thiocyanate reacting according to the following equation:

$AgNO_3 + KCNS = KNO_3 + AgCNS.$

Ferric chloride solution is used as an indicator—turning red when the end point is reached."

Here are ranges of atmospheric concentrations of phosphine published in the literature.

	PHOSPHINE — PARTS PER MILLION
Rapidly fatal	200 — 2000
Odor perceptible	1 — 20
Maximum allowable concentration	0 — .05 (U.S. Govt. Industrial Hygienists)

I wish I were sure of an analytical method that can accurately detect 0.05 parts per million.

It is even difficult to analyze phosphine by mass spectrography because of interference by water vapor, oxygen or ozone. This is because the phosphine molecule has a weight of 35 and the water-oxygen molecule a weight of 34, which does not yield a large enough weight difference for spectrographic separation.

Since 1900, only 59 cases of phosphine poisoning have been reported and of these 26 were fatal. Most of these were crew members on freighters carrying ferrosilicon.

No cases of phosphine poisoning have, to my knowledge, occurred among foundrymen.

*Transactions of the Association of Industrial Medical Officers, V.8, July 1958 pp 50-53

for the asking

Continued from page 132

Industrial lubricant . . . need is subject of 20-p bulletin reportedly aiding in selecting right lubricant for the job. *Keystone Lubricating Co.*
Circle No. 145, Page 155-156

Vibration control . . . for all types of machinery is discussed in booklet. Includes case histories and cost reduction results. *Felters Co.*
Circle No. 146, Page 155-156

Tramp iron . . . removal by magnetic separation discussed in brochure. *Stearns Magnetic Products.*
Circle No. 147, Page 155-156

Nickel alloy castings . . . fabrication outlined in brochure. *Continental Copper & Steel Industries, Inc.*
Circle No. 148, Page 155-156

Wet blast finishing . . . equipment presented in new bulletin depicting applications. *Techline Div., Wheelabrator Co.*
Circle No. 149, Page 155-156

Cranes . . . for heavy industrial use offered in illustrated brochure showing installation and applications. *Manning, Maxwell & Moore, Inc.*
Circle No. 150, Page 155-156

Abrasive cutting . . . demonstration laboratory described in 6-p folder. *Allison-Campbell Div., American Chain & Cable Co.*
Circle No. 151, Page 155-156

Iron briquette production . . . by new process allowing direct feeding into furnaces is explained in 12-p brochure. *R-N Corp.*
Circle No. 152, Page 155-156

Core ovens . . . utilizing dielectric heating reportedly provide fast, uniform baking in minutes. Circle number below for bulletin. *Foundry Equipment Co.*
Circle No. 153, Page 155-156

Use of silicones . . . in the shell molding industry is described in 4-p data sheet covering three silicone parting agents. *Silicones Div., Union Carbide Corp.*
Circle No. 154, Page 155-156

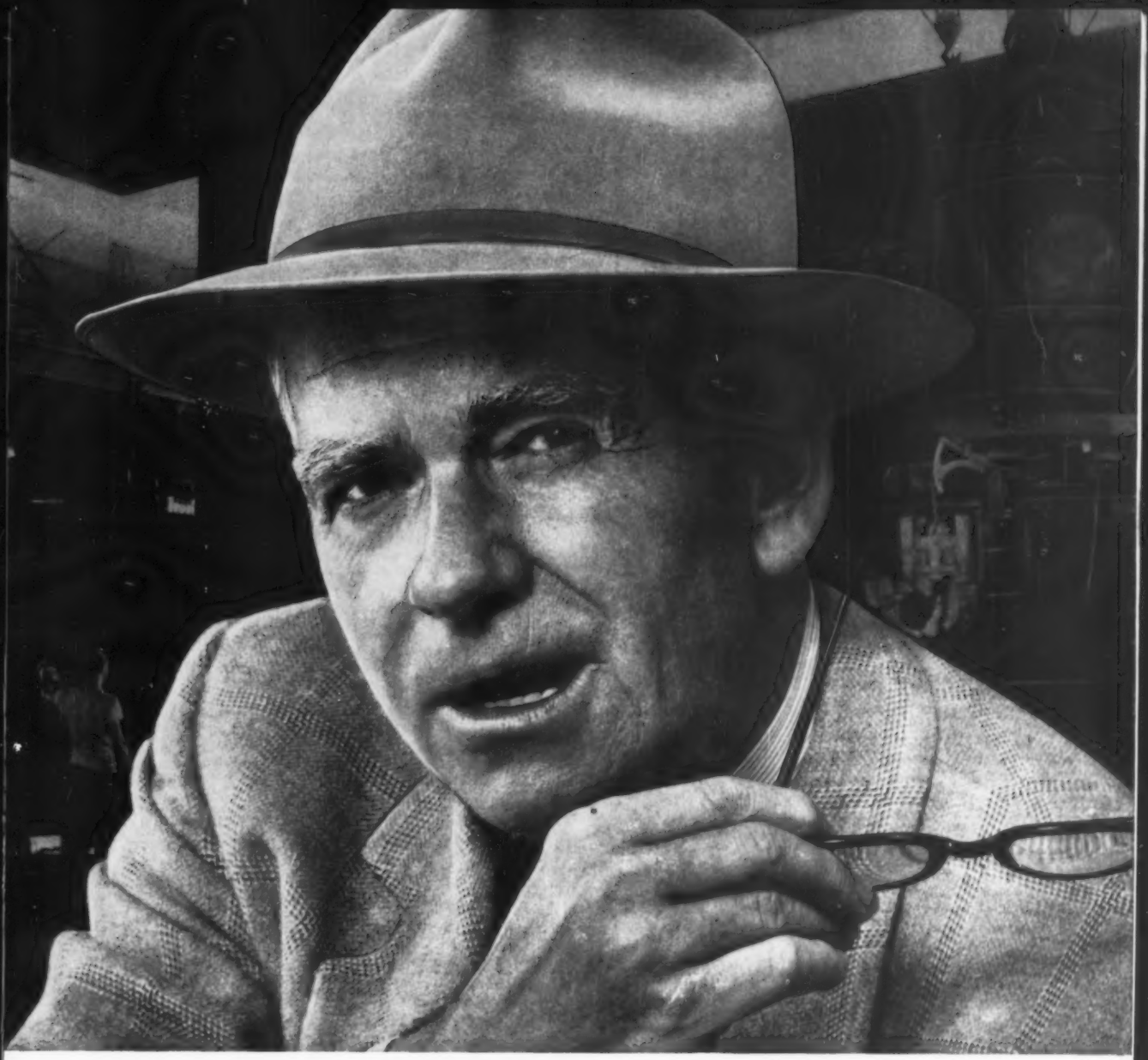
Dust control . . . systems outlined in brochure recommending systems for plants with individual problems. *Pangborn Corp.*
Circle No. 155, Page 155-156

Die-casting machines . . . illustrated and described in brochure. Also, a 4-p folder interpreting the Shaw Process. *DCMT Sales Corp., Div. British Industries Corp.*
Circle No. 156, Page 155-156

Radiant heat protection . . . for foundry workers with aluminized fabric discussed in brochure. Use circle number below. *Minnesota Mining & Mfg. Co.*
Circle No. 157, Page 155-156

Abrasive cutting . . . machine reportedly cuts practically all metals. Use circle

Continued on page 136



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Iron and steel foundry operators are cutting chromium costs by using ELECTROMET's new low-cost refined charge chrome for all high-carbon chromium additions. Inventory, handling, and storage are greatly simplified by stocking only this one high-carbon chromium alloy. It is ideal for use as:

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Refined charge chrome combines the economy of regular charge chrome with the maximum cleanliness and low residual element content of conventional high-carbon ferrochrome. For facts on how refined charge chrome can reduce your costs, contact your ELECTROMET representative.

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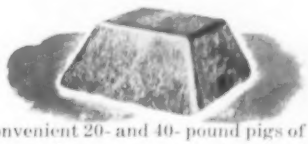

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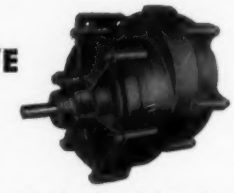

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AJAX FLEXIBLE COUPLING CO. INC.
WESTFIELD, N. Y.

Circle No. 251, Page 155-156

for the asking

Continued from page 134

number below. *Allison-Campbell Div., American Chain & Cable Co.*
Circle No. 158, Page 155-156

Investment castings . . . how to buy them is the subject of booklet outlining whether a part should be considered for this process. *Mercast Mfg. Corp.*
Circle No. 159, Page 155-156

Business improvement . . . is discussed in 8-p booklet of consultant firm. Charts, checklists and other managerial data. *E. Norman Kagan Co.*
Circle No. 160, Page 155-156

take the plunge!
get your own copies of these manufacturer's publications. circle numbers on the card on the last page of this issue

Heavy-duty grinding . . . unit features maneuverability and lightweight operation. Use circle number for brochure. *Grinding and Polishing Machinery Corp.*
Circle No. 161, Page 155-156

Mineral company . . . products listed in brochure, including fluxes, lubrication materials and metal alloys. *Foote Mineral Co.*
Circle No. 162, Page 155-156

Flowability . . . and ramability are differentiated in company newsletter. *American Colloid Co.*
Circle No. 163, Page 155-156

Shaw Process . . . explained in bulletin which illustrates applications of precision casting technique. *Shaw Process Development Corp.*
Circle No. 164, Page 155-156

Microstructure . . . of gray iron castings illustrated in 12-p booklet showing micrographs of castings with from 31,500 to 63,000 psi. To obtain, use circle number below. *Herbert A. Reese & Associates.*
Circle No. 165, Page 155-156

Metal castings . . . uses and advantages pointed out in question and answer form in 28-p booklet covering malleable iron, pearlitic malleable iron, gray iron, aluminum and magnesium. *Dayton Malleable Iron Co.*
Circle No. 166, Page 155-156

Tape recordings . . . of technical talks on many facets of the metal castings industry are available from AFS. Includes discussions on cupola operation, air pollution control, self-curing oil binders, producing

Continued on page 138

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FOR BETTER CASTINGS...
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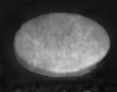
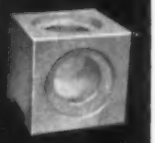

Splash Cores

Strainer Cores



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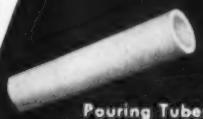
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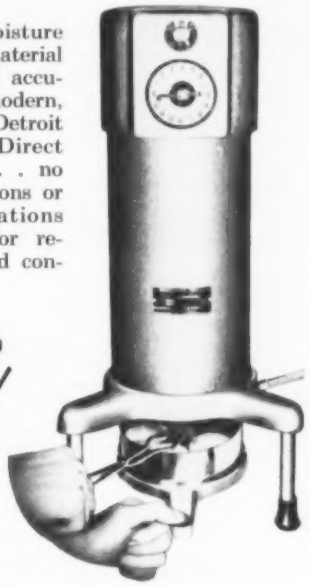

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Sample	Sample Size Grams	Temperature Degs. F.	Drying Time Minutes
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Paper	50	250	15
Salt	20	260	6
Soap	10	250	9
Color Pigment	10	212	12
Liquid Wax	5	250	15
Yeast	50	280	15
Licorice Extract	5	220	30
Pig Meal	25	250	25
Mash Pellets	25	255	25
Pulverized Oats	25	255	10
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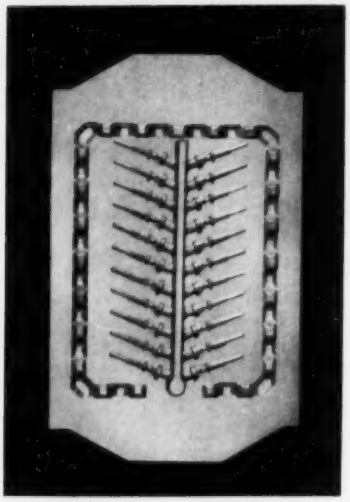

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Circle No. 254, Page 155-156

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Continued from page 136

quality castings and many more. Circle number below for complete listing and prices. *American Foundrymen's Society.*
Circle No. 167, Page 155-156

Training courses . . . pertinent to every type of metalcasting work are offered by the AFS Training and Research Institute. For free brochure covering all courses offered, circle number below on Reader Service card, last page. *American Foundrymen's Society.*
Circle No. 168, Page 155-156

Index . . . to 1958 Modern Castings with cross references by subject, title and author available. *American Foundrymen's Society.*
Circle No. 169, Page 155-156

Foundry operations . . . in large permanent mold and die casting foundry described in brochure. *Monarch Aluminum Mfg. Co.*
Circle No. 170, Page 155-156

Scrap removal . . . from chipping and snagging tools accomplished automatically with conveyor which continuously removes hot, wet or dry chips from machines. Use circle number below for brochure. *May-Fran Engineering, Inc.*
Circle No. 171, Page 155-156

Pyrometer . . . indicating-controlling, featured in brochure pointing out specifications. Includes "high and low target" model. *Illinois Testing Laboratories, Inc.*
Circle No. 172, Page 155-156

Shell core . . . and mold blowers, two-station full automatic-type, featured in folder describing core and mold making machines. *Sutter Products Co.*
Circle No. 173, Page 155-156

Sand aeration . . . blending and mixing equipment featuring magnetic separation illustrated in 4-p brochure. *Royer Foundry & Machine Co.*
Circle No. 174, Page 155-156

Sand mixer . . . featuring rubbing action described with specifications in folder. *Archer Daniels Midland Co.*
Circle No. 175, Page 155-156

Oxygen analyzer . . . for steel, titanium, tungsten and other metals and alloys detailed in brochure. *Laboratory Equipment Corp.*
Circle No. 176, Page 155-156

Industrial valves . . . 28-p catalog indexed for quick reference by topics. Includes pressure temperature charts. *Ohio Injector Co.*
Circle No. 177, Page 155-156

Power sweeper . . . with 5-ft., 6-in. turning radius and featuring hand vacuum attachments covered in 4-p brochure. *Patch & Kase Corp.*
Circle No. 178, Page 155-156

Universal tester . . . for multi-low-range testing in tensile, compression, transverse and shear on any low-strength industrial material. Request bulletin. *W. C. Dillon and Co.*
Circle No. 179, Page 155-156

Refractory . . . strainer cores, breaker cores, gate tiles, tees and ells presented in catalog. *Louthan Mfg. Co.*
Circle No. 180, Page 155-156

Eye shields . . . catalog, 48-pp, includes information on correct lens selection as well as complete line of products. *Chicago Eye Shield Co.*
Circle No. 181, Page 155-156

Free reprint . . . an article in four parts on cutting costs with grinding wheels. Reprinted from 1957 MODERN CASTINGS and authored by J. A. Mueller, Carborundum Co. *American Foundrymen's Society.*
Circle No. 182, Page 155-156

Shell molding . . . process, how it differs from green sand practice, is explained in feature article from MODERN CASTINGS which is available free when you circle number below on the Reader Service Card, last page. *American Foundrymen's Society.*
Circle No. 183, Page 155-156

Metallurgical control . . . of metal structure is one of services company offers to foundries. Booklet describes services and engineering properties offered by irons produced by company's process. *Sorbo-Mat Process Engineers.*
Circle No. 184, Page 155-156

training films

■ **The following list of motion pictures and film strips will prove useful in educating your personnel to better perform their jobs. Circle the appropriate number on the Reader Service Card (page 7-8) for complete information regarding these films. Items indicate whether films are available free of charge, by rental or by purchase only.**

Industrial Exhaust Systems . . . Types of hoods, baffles, elbows and fans being used are demonstrated, with emphasis on selecting proper exhaust unit for function to be performed. Sixteen mm, black and white, sound, 12 min, rental. *University of Michigan, Audio-Visual Education Center.*
Circle No. 185, Page 155-156

Foundry Flexibility, shows a highly efficient mechanical handling system for producing wide variety of castings with frequent changes in production requirements. Includes, among other operations, high speed automatic shell molding. Color, sound, 16mm, free, 29 min. *Link Belt Co.*
Circle No. 186, Page 155-156

A Study of Vertical Gating Design, demonstrates technique to reduce turbulence to minimum during pouring of castings with height if at least 30 in. Color, sound, 16 mm, 15 min., rental. *American Foundrymen's Society.*
Circle No. 187, Page 155-156

Technique for Tomorrow, depicts processing operations conducted at company's foundry. Black and white, 16 mm, sound, 20 min., free. *Ford Motor Co., Training Div.*
Circle No. 188, Page 155-156

PERMABRASIVE®

are you *Satisfied* with your blast cleaning operation?

Even if you believe you are getting good results now, you cannot afford to hang out the "Do Not Disturb" sign. If you are interested in cleaning speed, finish, abrasive consumption, or maintenance costs, listen to this:

NATIONAL has learned to control its melts to such a fine point, that we are able to turn out abrasives with controlled characteristics and predictable results ton after ton after ton. **PERMABRASIVE**®, the pearlitic malleable abrasive, annealed practically a pellet at a time, is enjoying a ten year record of saving money for thousands of cost-conscious customers.

Here's what this means: If you are using steel abrasives, **PERMABRASIVE**® can save you money, because of its faster cleaning action and lower cost per ton. If you are using ordinary annealed abrasives you can save money by buying **PERMABRASIVE**®, because of its faster cleaning action, minimum graphitic carbon, and longer life, because of its low phosphorus content. And—where special problems call for a custom-designed abrasive—NATIONAL can and does produce it, because of a decade of experience in the fine art of controlling its melts. Simply put: our metallurgists KNOW what it takes to get certain results and KNOW how to build it into our shot and grit.

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We also make **PERMA-STEEL**®, the low cost "work-horse" of the long-life abrasives, which may fit your special operation perfectly to produce many of the same cost-cutting advantages. If you have an application that calls for a chilled iron shot and grit, try our **CONTROLLED "T"**®, the "iron fist in a velvet glove." In short, NATIONAL makes an abrasive to cover every possible blast cleaning need.

FREE: the NEW "Second Reader on the use of shot and grit." Write for your copy.

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Circle No. 255, Page 155-156

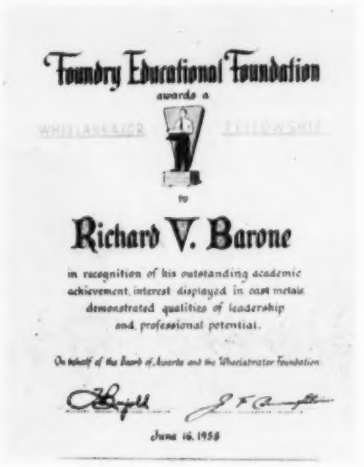
foundry trade news

FOUNDRY EQUIPMENT MANUFACTURERS ASSOCIATION INC. . . . held their 40th Annual Meeting at the Greenbrier, White Sulphur Springs, W. Va., October 16-18. More than 125 manufacturers of equipment and supplies used in the foundry industry attended. G. E. Seavoy, vice-president, Whiting Corp., Harvey, Ill., was re-elected president. E. A. Borch, vice-president, National Metal Abrasive Co., Cleveland was re-elected 1st vice-president; R. A. Brackett, Spencer Turbine Co., Hartford, Conn. was elected 2nd vice-president. C. R. Heller, Washington, D. C., was re-elected executive secretary-treasurer. Elected to the board of directors were: P. A. Burns, Robins Conveyor Div., Hewitt-Robins Inc., Passaic, N. J.; J. F. Connaughton, president, Wheelabrator Corp., Mishawaka, Ind.; B. L. Simpson, president, National Engineering Co., Chicago. The meeting centered on blast cleaning and tumbling; dust and fume control; flasks; furnaces and accessories; material handling and processing and molding machines. *Marketing of Foundry Equipment* was a feature of the meeting with R. A. Brackett acting as moderator. Panel members were Gordon Seavoy, Philip Bauer, Allis-Chalmers International, Milwaukee; George Pope, Foundry, Cleveland and David Davidson, Link-Belt Co., Chicago. The key speaker of the three-day event was R. L. Gilmore, Superior Steel and Malleable Castings Co., Benton Harbor, Mich., who spoke on *Meeting Today's Requirements for Quality Foundry Products.* E. A. Borch presided at the general session on the third day and analyzed the *Rate of Activity in the Foundry Equipment Industry.*

STEEL FOUNDERS' SOCIETY OF AMERICA . . . Cleveland, held the 1958 Product & Market Development Divisional Conference at the Drake Hotel, Chicago. Oct. 24. Keith Millis, International Nickel Co., New York, spoke before the conference on subject of *Ductile Iron Properties and Applications.* David Miller, Falk Corp., Milwaukee, spoke about *Cast Weld Construction and Composite Fabrication.* J. B. Caine, consulting engineer, Cincinnati, Ohio, discussed, *Engineer.*

Left to right: J. M. Ritter, Farrell-Cheek Steel Co., Sandusky, Ohio, member S.F.S.A. product and market development committee representing division 5 and co-chairman of conference; J. B. Caine; David Miller; J. W. Perry, Jr., Grede Foundries, Inc., Milwaukee, and S.F.S.A. director representing division 6; W. H. Shinn, Gunite Foundries Corp., Rockford, Ill., member S.F.S.A. product and market development committee and co-chairman of the meeting; Keith Millis and G. K. Dreher, market development director S.F.S.A., Cleveland.

FOUNDRY EDUCATIONAL FOUNDATION . . . applications are now being accepted for the 1959 F.E.F. —Wheelabrator Fellowship Awards. The Wheelabrator Foundation, in cooperation with F.E.F., established this graduate study program last March granting 50 Fellowships over the next several years, each valued at $1500. Program will assist outstanding young men in obtaining graduate-level education in fields of engineering, science, business administration and marketing or other areas having a definite connection with the castmetals industry. Ultimate objective of program is contributing to advancement of foundry industry by providing graduate-level educational opportunities for industry's potential leaders.


Foundry Educational Foundation
awards a
to
Richard V. Barone
in recognition of his outstanding academic achievement, interest displayed in cast metals, demonstrated qualities of leadership and professional potential.
On behalf of the Board of Awards and the Wheelabrator Foundation
June 16, 1958

Eligible to apply are senior undergraduate students and graduate students who are now registered with F.E.F.; men returning from military services who were registered with F.E.F. or employed in foundry industry prior to military service and men employed in foundry or allied industries. Applicants must not be more than 28 years old on date of application. Applications may be obtained from F.E.F. in Cleveland or from key professors at 17 Foundation schools, not later than Dec. 1, 1959. Board of Awards will select Fellowship winners on basis of applicant's interest in castmetals industry, his capacity for graduate study, his character, personality and need for financial assistance. The 1959 awards will be made Feb. 1, 1959.

CAST BRONZE BEARING INSTITUTE . . . Evanston, Ill. held an open meeting Sept. 18 at the Franklin Institute, Philadelphia, where manufacturers attending learned that infinite sleeve bearing life is possible. Meeting high-light was discussion of bronze sleeve bearing design by Dr. Dudley Fuller, machine design department, Columbia University and consultant, Franklin Institute. Fuller illustrated his remarks with examples showing how sleeve bearings had solved serious bearing problems. He commended C. B. B. I. for commissioning the Franklin Institute to prepare a much needed manual of technical information on cast bronze sleeve bearings for design engineers. Harry Ripel, project engineer, Franklin Institute, reviewed studies being conducted for C. B. B. I. Activities also include distribution of the manual, an advertising program to publicize engineering advantages of cast bronze sleeve bearings, educational courses for engineers at principal cities throughout the country and providing educational material for under graduate study.

AMERICAN WELDING SOCIETY . . . New York, has established a center for the dissemination of welding news and information which will be of substantial benefit to both press and industry in checking technical accuracy, verifying news items, obtain-

ing additional facts and details and obtaining photographs to illustrate material.

BRASS AND BRONZE INGOT INSTITUTE . . . Chicago, set up a technical service program in cooperation with its member firms to offer technical guidance and counsel to manufacturers and users of copper-base castings. The program is aimed at product improvement and market expansion.

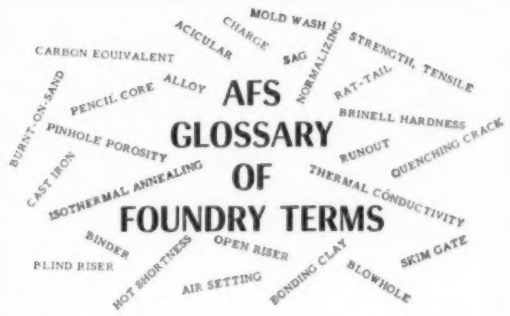
CHICAGO FOUNDRYMEN'S ASSOCIATION . . . elected J. K. Hodgson, Hodgson Foundry Co., Chicago, president at its annual meeting held in November. H. R. Erickson, Noonan-Malstrom Co., Chicago, was re-elected vice-president and H. J. Leddy, Joliet Foundry, Div. Infilco, Inc., Joliet, Ill., was re-elected secretary-treasurer. Mildred Kosar is executive secretary.

ARMOUR RESEARCH FOUNDATION . . . of Illinois Institute of Technology dedicated a $1,200,000 addition to the Metals Research Building in October which marked the completion of the second step in a 10-year expansion program begun early in 1956. This is the 24th new building and will more than double the department's space for metal projects.

The program included a luncheon for the members of the board of trustees and administrators of the foundation and representatives of industrial and research organizations concerned with metals research. Main speaker was Dr. J. H. Hollomon, manager of metallurgy and ceramics, General Electric Research Laboratory, who spoke on Materials Research. Dr. D. J. McPherson, discussed The Growth of Metals Research at ARF. Dr. J. T. Rettaliata, president of IIT and Armour Research, presided.

Continued on page 142

FOUNDRY EDUCATIONAL FOUNDATION Industry Advisory Board for the Chicago Undergraduate Division of the University of Illinois. Left to right: F. W. Trezise, Assoc. Dean of Engineering; Herb Scobie, Sec. Non-Ferrous Founders' Society; Richard Olson, Dike-O-Seal Inc.; Otto Harer, Atlas Match Plate Co.; J. H. Berstrand, Lester B. Knight & Associates; Lou Englebaugh, Herman Worrell, National Malleable & Steel Castings Co.; George Edwards, Woodruff & Edwards; Professor R. W. Schroeder; Professor R. B. Perkins; Robert Parker, Woodruff and Edwards; E. J. Walsh, executive director, F.E.F.; Jack Schaum, editor, MODERN CASTINGS; Alexander Zeumer, F.E.F. Scholarship Student; Arnold Alek, Howard Foundry Co.; A. C. Smith, American Steel Foundries; Ronald Acker, Hansell & Elcock and F. Steinebach, F.E.F. vice-president.



Including almost 2000 terms, this book is intended to help standardize the meanings of foundry terms throughout the metal castings industry. In its preparation, reference was made to many presently existing glossaries and dictionaries of scientific and engineering terms. IT IS THE MOST COMPLETE WORK OF ITS KIND and should be at the finger-tips of every member of the metal castings industry. (80 pp. 6 x 9 Paper Bound.)

AFS MEMBERS $.75 NON-MEMBERS $1.25

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Continued from page 141

NATIONAL FOUNDRY ASSOCIATION . . . members gathered for their 60th Annual Meeting at the Drake Hotel, Chicago, Nov. 20-21. Charles T. Sheehan, N.F.A. Executive Secretary, in speaking on *Labor Negotiations in the Foundry Industry*—1959, listed what management can expect labor to request in the coming year: increased wages, more vacation benefits, health insurance plans and paid holidays.

Newly elected members of Administrative Council, to serve for three years, are: J. F. Campbell, Campbell Foundry Co., Harrison, N.J.; J. W. Meyer, Interstate Foundry Co., Indianapolis, Ind.; L. L. Stouffer, Pangborn Corp., Hagerstown, Md.; C. V. Nass, Pettibone-Mulliken Corp., Chicago; D. R. Gochnour, Marion Power Shovel Co., Marion, Ohio; A. R. Janes, Jr., Standard Foundry Co., Racine, Wis.; and R. L. Jackson, Jackson Industries, Inc., Birmingham, Ala.

The rising cost of Workmen's Compensation costs were explained by D. F. Stevenson, Attorney-at-Law, in a talk entitled, *Rising Workmen's Compensation Costs—A Continuing Puzzle*. A primary reason for rising costs is, according to Stevenson, the fact that free choice of doctor by injured employee is being accepted in several states, and the employer is required to continue his financial obligation as long as the employee continues treatment.

A Successful Foundry Safety Program which has done much to make safety consciousness an integral part of everyday operations at the Greenlee Foundry Co., Chicago, was discussed by W. G. Greenlee, president of the foundry, and N.F.A. treasurer. The company has currently achieved a 16-month period without a lost-time accident under the safety program supervised by employees; initiative for the program stems from management entirely, which has full responsibility, financial and otherwise.

Allan Slichter, President, Pelton Steel Castings Co., Milwaukee, and AFS national director, discussed *An Effective Communications Program* at his firm. He brought with him many examples of the use of the company trademark in creating better customer and employee relations.

He put on a baseball-type cap and jacket bearing the Pelton trademark which salesmen wear on calls; the cap is worn as the shop cap by plant personnel. Included in Slichter's "department store" were items such as jackets, shirts, goucho ties, ash trays, etc., which the company gives as birthday presents to personnel and customers. Infant jerseys and baby blankets are sent to new arrivals. The Pelton trade-mark, finding a place in every employee home, reportedly serves to strengthen the good management-employee relationship which exists at the plant.

Other speakers included J. K. Langum, Business Economics, Inc., Chicago, *Economic Conditions and Business Prospects;* and Rev. Frederick Becka, St. Theresa's Chinese Mission, Chicago, and former missionary to China, speaking on *China and Communism*. Also included in the two-day program was a panel session moderated by E. F. Schlickman, director, industrial relations research, N.F.A., discussing the subject, *Cost-Saving Improvements in Labor Agreements*.

CONVEYOR EQUIPMENT MANUFACTURERS ASSOCIATION . . . Washington, D. C., elected J. B. Nordholt, Jr., Webster Mfg., Inc., Tiffin, Ohio, president during the 25th Annual meeting at the Greenbrier, White Sulphur Springs, W. Va. E. H. Woodberry, Lamson Corp., Syracuse, N. Y., was elected vice-president; L. J. Johnson, Mathews Conveyor Co., Ellwood City, Pa. was elected treasurer; and E. E. Saperston, Mechanical Handling Systems Inc., Detroit, was elected secretary. Directors for the new year are O. A. Johnson, Gifford-Wood Co., Hidson, N. Y.; H. A. Barber, Barber-Greene Co., Aurora, Ill.; and E. P. Berg, Link-Belt Co., Chicago. R. C. Sollenberger was re-elected executive vice-president to head staff operations. L. R. Boulware, General Electric, told CEMA members to become more active in politics, and following his talk the executive committee asked Mr. Sollenberger to study means by which the association could be of service to members in educating the public on broad political and economic issues.

C. W. Stewart, Machinery & Allied Products Institute, urged more aggressiveness in pursuit of foreign markets.

Hevi-Duty Electric Co. . . . Milwaukee, purchased Stroman Furnace & Engineering Co. from Peterson Oven Div., Baker-Perkins, Inc. The addition of this established line of furnaces will complement the furnace division purchased from Eclipse Fuel Engineering Co., in July, 1958. Purchase adds reverberatory furnaces for holding molten metals used in die casting and permanent molding industry. A newly developed automatic slug-casting machine is one of the important products included in the acquisition. All equipment formerly produced by Stroman will be manufactured in the new Hevi-Duty plant at Watertown, Wis.

Howard Foundry Co. . . . Chicago, has been named by Chemical Contour Corp., Downey, Calif., as first licensee to use its processes and etchant compositions for chemical milling of castings. The process originally developed for sculpturing aluminum sheet and plate has been successfully applied to wall-thickness-reduction of castings. This highly-specialized approach enabled the firm to mill aluminum and stainless steel-alloy castings which, until recently, were considered impossible because they tended to develop porous surfaces with etchants used. Fifty-one different etchants for 62 alloys have been made and more are under development. Etchants smooth and polish as-cast surfaces and provide uniform metal removal from all exposed casting surfaces. Howard Foundry, supplier of aircraft castings for many years, was selected as first licensee after review of production facilities and laboratories.

Reynolds Metal Co., . . . Richmond, Va., forsees an increase in the average pounds of aluminum per car in the next three years which will overshadow substantially the growth which has taken place in the last decade when the per-car average of aluminum use rose more than 600 per cent. D. P. Reynolds,executive vice-president of Reynolds, stated the General Motors announcement that aluminum has been highly competitive with cast iron for automobile construction is the most encouraging news for the aluminum industry since they revealed successful tests on V-8 aluminum engines last summer.

American Hoist & Derrick Co. . . . purchased the entire capital stock of **Valley Iron Works,** combining two of the oldest manufacturing enterprises in St. Paul, Minn. These companies have long been closely associated. Valley has been an important subcontractor to American Hoist and the two plants are located on adjacent property. Valley will continue to operate under its own name as a subsidiary, with H. M. Patton as general manager. Stuart Cameron, Jr., who has managed the firm, will be retained.

Carborundum Co. . . . Niagara Falls, N. Y., board of directors authorized

Continued on page 152

FOR CLARK BROS. CO. MANIFOLD CASTINGS

30% LESS CORE-MAKING TIME

50% LESS CORE-UP TIME

40% LESS CLEANING TIME

Use of Kold-Set provides smoother casting surfaces, together with dramatic cost savings, for Clark Bros. Co. in production of manifolds for R A Type Compressors.

Core: Bed-in sand and driers are not needed. The cores retain excellent dimensional accuracy.

Core Setting: Conventional methods require one core setting for fitting, as well as a re-setting. Only a single setting is needed with Kold-Set.

A good deal of core rubbing has been eliminated and there is no bed-in sand to remove. This results in a better core surface while lessening the chance of loose bed-in sand causing dirt in the casting.

Casting and Cleaning: Casting surfaces are smoother due to eliminaton of bed-in sand. Hydro-blast time has been reduced by 50%, and there is less finish chipping. Due to superior venting in the Kold-Set sand mix and less gas potential in the cores after baking, blows in the cope of the casting have been eliminated.

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G. E. SMITH, INC.

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ORIGINAL AND EXCLUSIVE MANUFACTURERS OF THE KOLD-SET PROCESS IN THE UNITED STATES

Circle No. 257, Page 155-156

let's get personal

Continued from page 128

engineering department, recently formed. He will coordinate efforts of all design development personnel in Cooper Alloy's Valve & Fitting, Foundry Products and Vanton Pump divisions. **D. C. Huber** has been appointed director of sales promotion and market research for the firm and will be responsible for advertising, promotion and market research activities of the company. He succeeds **S. F. Cooper,** who has been appointed castings sales manager. In his position Cooper will head the field sales development and management for the company's high-alloy commercial castings.

John Walsh . . . has joined Midwest Aluminum Co., Cleveland, Ohio. He is a member, AFS Northeastern-Ohio Chapter and was formerly with Apex Smelting Co.

J. P. O'Neill . . . has accepted a new position with Malcolm Foundry Co., Newark, N. J. He is a member, AFS Metropolitan Chapter.

J. E. Kranz . . . has accepted the position of works manager for Lectromelt Castings Div., Akron Standard Mold Co., Akron, Ohio. He is a member, AFS Canton District Chapter.

H. J. Heine . . . has been named technical director for the Malleable Founder's Society, Cleveland. He will coordinate and supervise Society

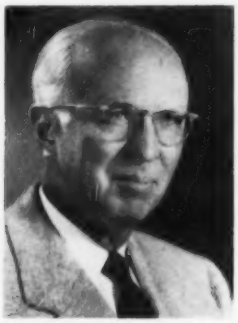
H. J. Heine

research and technical activities. Heine served as technical and research director of American Foundrymen's Society for three years and was most recently a member of the executive staff of the American Society for Metals.

L. C. Gleason . . . former foundry manager of Gleason Works, Rochester, N.Y. is now president of Gleason Works. He has been in the foundry business for 25 years.

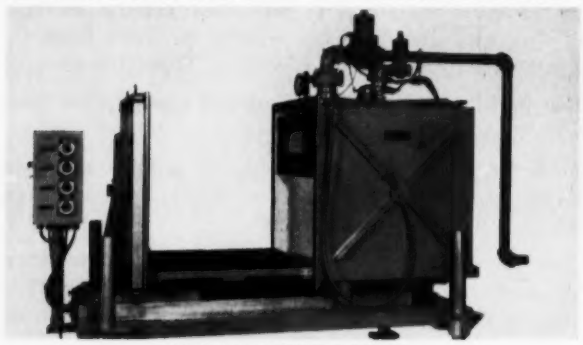
R. H. Ebersole . . . has been appointed district manager of the Detroit sales office, Federated Metals Div., American Smelting & Refining Co. He is a member, AFS Detroit Chapter and the Society of Die Casting Engineers.

R. S. Hammond . . . vice-president in charge of Whiting Corp., Chicago office, retired after 40 years of service



R. S. Hammond

with the firm. Whiting served as president and director of the Foundry Equipment Manufacturer's Association.



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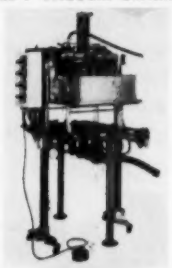
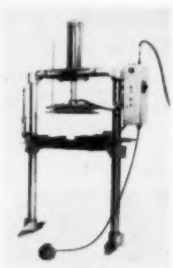
MODEL ER VACUUM CHAMBER



MODEL M VACUUM CHAMBER



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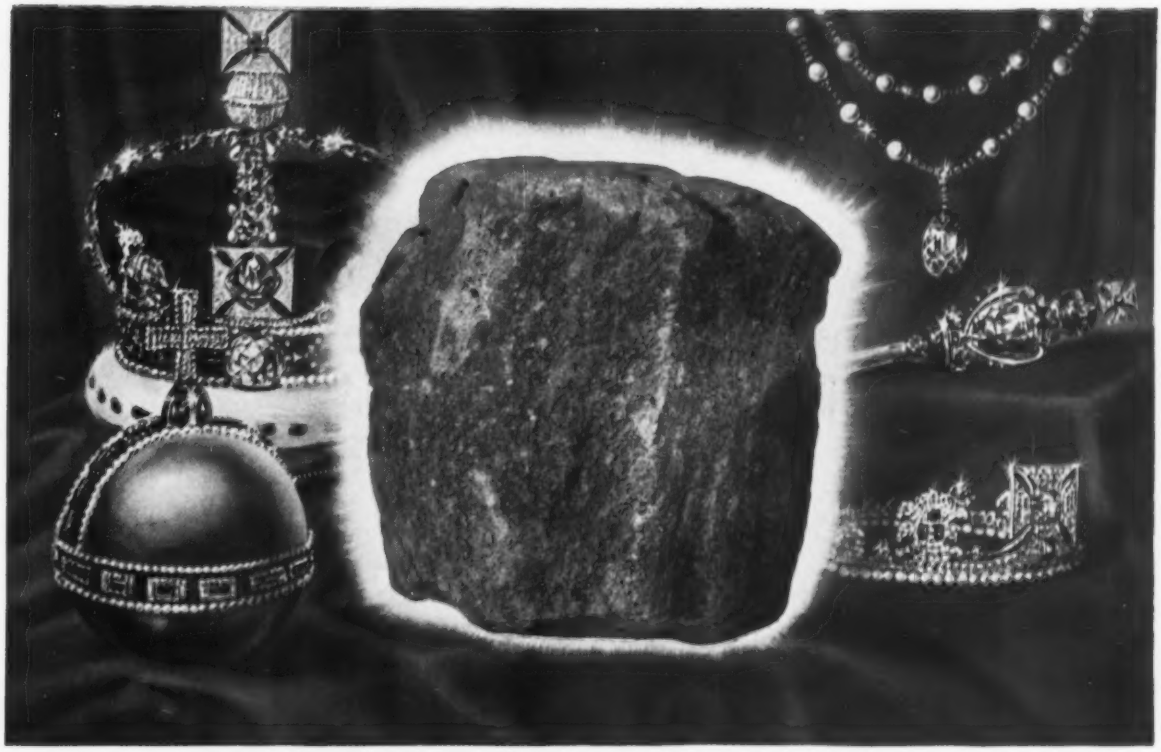

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Semet-Solvay is the *only* merchant Coke producer operating four By-product Coke plants ready to supply all the high quality Foundry Coke you need *when* you need it! Its facilities include 700 ovens, 3 coal mines and a fleet of barges and diesel boats. And *you* get first call on our output—we have *no* prior commitments to others.

In addition to accessibility, the purchase of your Foundry Coke from Semet-Solvay has many other advantages: Quality and uniformity of product are tops because of Semet-Solvay's continuous and exhaustive research program. Availability is constant, thanks to Semet-Solvay's extensive productive facilities. Five coke sizes are available to meet the requirements of all sized cupolas and melting practices. And last but not least, we offer advice—a free metallurgical service department staffed by specialized technicians. Their advice is yours for the asking.

Call your Semet-Solvay office today or write us direct for the *complete* story on Semet-Solvay Foundry Coke. You'll find it both interesting and profitable.

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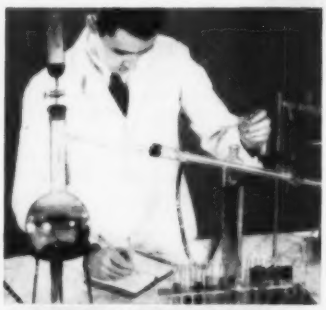
Allied Chemical

Circle No. 259, Page 155-156

Order KOPPERS Premium Foundry Coke

Premium quality foundry coke! That's exactly what Koppers delivers car-after-car. Made from the highest quality West Virginia coals, scientifically blended and baked the right length of time, Koppers Premium Foundry Coke is absolutely *uniform* in *size, strength, structure* and *chemical analysis*. With its higher carbon content, Koppers Coke enables the foundryman to maintain a higher temperature range, thus increasing the the cleanliness of the iron. This in turn, helps reduce fuel consumption and means lower operating costs all around. Next time *order* Koppers Premium Foundry Coke. Available anywhere in the U.S. or Canada in sizes to meet your needs. Koppers Company, Inc., Pittsburgh, Pa.



WE CHECK EACH DAY'S RUN to make certain you get foundry coke of the exact size and chemistry that is most efficient for the job. Analyses are available to your foundry on request.

Circle No. 260, Page 155-156

pouring off the heat

light for management

■ My compliments to you and your staff for the well-prepared presentation to your readers of the important function of preventive maintenance (September, 1958). It certainly will stimulate interest and enlighten management in the foundry industry on the importance of good maintenance. It has been said the traditional blindness of management in this respect is the cause for the lack of advancement in maintenance functions in industry today.

On behalf of the American Institute of Plant Engineers I want to thank you for promoting this maintenance function because it is one of the important functions of the plant engineer. Preventive maintenance is a topic of many discussions held by our chapters and your members are welcome to attend any of our meetings.

S. A. Simonson
Chicago Hardware Foundry Co. and President, American Institute of Plant Engineers
North Chicago, Ill.

onward and upward

■ Since its birth, this country's overall economic trend has been ever upward. It has to be—it is the inherent nature of the beast–and it always will be. It's as certain as the power of the sun. And every period of prosperity has been greater than the one before. The pauses in between let us catch our breath and give us a chance to ruminate. These pauses can be turned to good account or they can be frittered away.

Nobody questions the sagacity of the advice to prepare for scarcity in time of plenty. Isn't the reverse equally as wise: prepare for plenty in time of scarcity?

During boom times most of our energies are concentrated on production. During slack times a good part of our energies should be devoted to preparing our facilities for lower production costs and higher speed in anticipation of the next boom.

Any high school boy would consider these comments to be elementary. What do they mean to the foundry tycoon? They could mean the difference between riding the crest of the next prosperity wave or foundering in its undertow. Does anyone doubt that we will ever have prosperous times again? If so, he is selling America short and that is rather foolish. It doesn't even take courage to invest now in modern high-speed foundry production equipment – it just takes common sense and a little faith in our own judgement. It's like betting on a sure winner!

E. B. Redhead
Wm. H. Nicholls Co.
Richmond Hill, N. Y.

pride of work

■ Just finished reading the article "Work Simplification Is Organized Common Sense," by E. F. Pierce, in the October issue of Modern Casting. I thought MC readers might be interested in knowing how we have succeeded in getting more of our employees "into the act."

First off, we've found it necessary to make every employee's job an important one. That's where pride in work begins. If any employee feels the work he is doing is insignificant, you can't expect him to have much pride in his work. No one wants to spend day after day doing something he feels is unimportant.

We do it with well-placed compliments on the merits of the work the employees are producing as well as the excellence of each individual's achievements. We see to it that every magazine or newspaper article playing up the importance of the foundry industry is placed on the bulletin board. And just as important, the foreman and executives in our company never miss an opportunity in conversations with each individual to play up the importance of what that worker is doing.

Next, we've found it a good policy to cut down on the amount of actual supervision we expend on the job; "no more supervision than is necessary" is our rule here. The more each employee can work on his personal initiative, the greater pride he will take in his work. We're certain here that a sure way to kill that pride is to be standing over every individual constantly and telling him what to do.

Another step we've taken here is to consult employees before we make changes. That gives them a spirit of being part of the producing team in the foundry. Even when a decision has been made beforehand we talk it over with the employees involved. The important thing, we feel, is to make each aware that he has a sense of "ownership" in the job with which he has been entrusted. You'll be surprised, too, how often this will bring out some new

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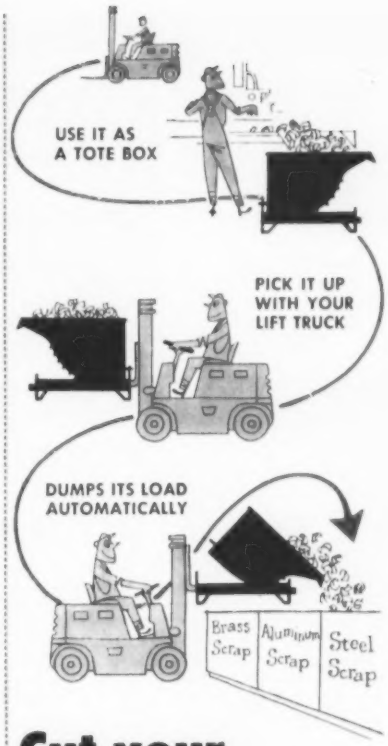

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Circle No. 261, Page 155-156

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	FOUNDREZ 7600, 7601, 7605	LIQUID AMINO CORE BINDING RESINS	RAPID COLLAPSIBILITY FAST BAKE — LESS SMOKING
	CO-RELEES 7300	LIQUID SAND CONDITIONER	EXCELLENT SAND WORKABILITY
	coRCIment 7990, 7991, 7992, 7993	LIQUID OLEORESINOUS CORE BINDERS	BROAD BAKING RANGE
	FOUNDREZ 7150, 7151	LIQUID PHENOLIC RESINS FOR SHELL COREMAKING	UNUSUAL STABILITY
	FOUNDREZ 7500, 7504, 7506, 7555	POWDERED PHENOLIC RESINS FOR SHELL MOLDING	SELF-ACTIVATION
	FOUNDREZ 7520	GRANULATED PHENOLIC RESIN FOR SHELL MOLDING	HIGH TENSILE STRENGTH
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STEEL STAINLESS LOW CARBON HIGH CARBON	**FOUNDREZ** 7104	LIQUID PHENOLIC CORE BINDING RESIN	EXCEPTIONAL STABILITY HIGH HOT STRENGTH HIGH BAKED STRENGTH
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Circle No. 266, Page 135-156

Pouring off the heat

Continued from page 147

ideas neither you nor the boys in the front office had thought of!

That brings up another point of procedure we have around here—give the individual employee every opportunity to try out new ideas of his own. Of course, you have to hold some checkrein over that sort of a program. Our method is to make sure that every employee knows he is encouraged to work out such ideas on his own but not to actually try them out before first consulting with his foreman or supervisor. Here again you have the point of developing the feeling of "belonging" and "ownership of the job" which is mighty important in building employee pride in the work they are doing.

The individual is also encouraged to build up a personal pride in his machine or piece of equipment in the foundry. This gives that employee something to call his own. This works so well that in most cases the men in our foundry have developed pet names for their machines! A bonus from this attitude is the marked lowering of maintenance and repair costs on equipment. Employees take better care of such machines when an element of pride in the job is developed.

I think, too, that it is important the employee knows the ultimate good that comes from the work he produces. We do this to a large extent in our internal house organ. The bulletin board is also used. And we never neglect an opportunity to spread such information by word of mouth. The success of the company's product is too often kept confined to the front office and never released to the people who make the goods. When we realized this was important and started passing on such information we found it made a great deal of difference in the feeling of respect the employees had, not only for the company but for the work they were producing in the foundry.

The over-all efficiency of the department in which each person works is also important. Pride in one's work has a team element too and where "the team" is doing an exceptionally good job there's always a feeling of more importance in the work on the part of each employee. We encourage this by efficiency competition between various departments and see to it that information about the results is always before the employees. You not only have to make your own department as efficient as you can but it's important that the employees therein know about this.

Promotion from within the company rather than from outside is also a good policy. If your firm doesn't follow this procedure you might drop a hint in the front office about it. Some other things count too—fair and efficient leadership on your part and that of the top management people as well; safe and healthy working conditions.

Believe me, I know from experience that effort on my part toward giving employees more pride in their work not only pays off in better production at less cost, but it helps make my own job a much easier one. I'm sure you will find the same thing holds true in your foundry.

ERNEST W. FAIR

headlights for risers

■ I was surprised to see a mention of the use of auto headlights to increase riser efficiency in your "editor's field report" in the September, 1958 issue. This procedure was originally mentioned at the Heat Transfer Clinic at the 1958 Castings Congress to stir up a little discussion.

For the record I would like to point out that the remark was based on a few scattered tests done in several foundries and I have not sufficient quantitative data to back it up. The tests themselves were only done to demonstrate the proportion of heat loss by radiation from the upper surface of an open riser. To my way of thinking, these tests only prove the value of blind risers.

The "refinements" of using stainless steel reflectors or lining the headlights with aluminum foil were suggested at the session. I hope I did not indicate that I had actually used these "refinements", since that is not the case.

What I did mention at the session was that as the efficiency of the reflector was increased by moving it closer to the riser, there was a danger of it being overheated. This is the limiting factor in using such a device.

R. C. SHNAY
Canada Iron Foundries, Ltd.
Toronto

AFS Chapter Meetings

Continued from page 128

can Colloid Co., *"Closer Precision & Better Finish with Green Sand Molding."*

Western Michigan . . Jan. 5 . . Schuler's, Grand Haven, Mich. . . J. Schappert, Campbell, Wyant & Cannon Foundry Co., *"Supervision."*

Western New York . . Jan. 9 . . Hotel Sheraton, Buffalo, N. Y. . . V. M. Rowell, Harry W. Dietert Co, *"Foundry Sand Testing & Control."*

Wisconsin . . Jan. 9 . . Schroeder Hotel, Milwaukee . . *Panel: "Nondestructive Testing."*

FEBRUARY

Canton District . . Feb. 5 . . Elks Club, Alliance, Ohio . . H. F. Bishop, Exomet, Inc., *"Gating & Risering."*

Central Illinois . . Feb. 2 . . Vonachen's Junction, Peoria, Ill. . . R. T. Lewis, Keen Foundry Co., *"Are Your Costs Reliable?"*

Central Indiana . . Feb. 2 . . Athenaeum, Indianapolis . . C. E. Drury, Central Foundry Div., GMC, *"What's New in Castings Design."*

Chicago . . Feb. 2 . . Chicago Bar Association, Chicago . . *Gray Iron Group*: M. H. Horton, Material Engineering Div., Deere & Co., *"Operation of Acid & Basic Water-Cooled Cupolas"; Steel & Maintenance Group*: E. J. Prince, Kaiser Industries, Corp., *"New Oxygen Converter Process of Steelmaking"; Non-Ferrous Group*; K. A. Miericke, Baroid Div., National Lead Co., *"Oil-Bonded Molding Sands"; Pattern Group*: V. B. Roll, Kish Industries, Inc., *"Plastics for Pattern Equipment."*

Metropolitan . . Feb. 2 . . Essex House, Newark, N. J. . *Round Table Aluminum*: D. L. LaVelle, American Smelting & Refining Co.; *Steel*: R. W. Ruddle, Foundry Services, Inc.; *Gray & Nodular Iron*: F. C. Barbour, Republic Steel Corp.; *Brass & Bronze*: R. J. Keeley, Ajax Metal Div., H. Kramer & Co., *"What Foundrymen Should Know About Solidification to Insure Better Castings."*

Toledo . . Feb. 4 . . Heatherdowns Country Club, Toledo, Ohio . . H. E. Gravlin, Chrysler Corp., *"Light Metals vs. Ferrous Metals."*

Western Michigan . . Feb. 2 . . Bill Stern's, Muskegon Heights, Mich. . . G. O. Pfaff, Wheelabrator Corp., *"Reducing Blast Cleaning Costs" and Film "Steel Shot."*

Western New York . . Feb. 6 . . Hotel Sheraton, Buffalo, N.Y. . . W. Illuminati, International Automation Corp., *"New Developments in the Foundry" and Film, Automated Foundry in Switzerland.*

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It successfully resists the erosive and corrosive action of metals and slags, eliminating refractory inclusions from the casting.

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It resists the wetting action of molten metal and slag, permitting ladles to be cleaned of solidified metal and slag with little effort.

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Circle No. 262, Page 155-156

obituaries

E. O. Jones, personnel and public relations director, Belle City Malleable Iron Co., Racine, Wis., died Nov. 23.

E. O. Jones

In 1935, when the silicosis racket was at its height in the Middle West, AFS instituted its Safety & Hygiene Program, and Jones was loaned to AFS (then AFA) to organize and head the program. Through his efforts and those of James R. Allan, who retired from International Harvester in recent years, first information was developed on silicosis preventative measures for foundries; and a series of manuals dealing with the engineering aspects of safety and hygiene for foundry operations were prepared and published by the association.

With his clear thinking and drive Jones became a well-known figure in medical, scientific, legal and even legislative and union circles in leading the association's aggressive program to combat unwarranted claims for compensation and inducing foundries to clean up their shops and adopt their own preventative measures. In fact, the association organized a mutual insurance company, the Founders' Mutual Liability Company, for the protection of Illinois foundries, and then turned the enterprise over to commercial operators.

Jones also served as Treasurer of AFA in 1937-38 before returning to Belle City Malleable.

L. E. Koleman, 67, plant superintendent, Fremont Flask Co., Fremont, Ohio, died Oct. 18. He was appointed superintendent in 1941 and had served since then in that capacity.

R. D. Phelps, Sr., 69, President, Francis & Nygren Foundry, Chicago, died Nov. 4. He had served as president of the firm since founding it in the early 1900's. Phelps was a founder and past president of Founders Mutual Casualty Co., and past president of the Chicago Foundrymen's Association. He was a member, AFS Chicago Chapter.

E. M. Klopfliesch, 60, assistant superintendent of foundry maintenance, Allis-Chalmers West Allis Works, West Allis, Wis., died Nov. 1. Associated with Allis-Chalmers for 29 years, he had been works manager of the company's Boston plant before transferring to West Allis Works in 1954. Klophliesch was a member, AFS Milwaukee Chapter.

E. E. Roberts, 53, assistant purchasing agent, C. O. Bartlett & Snow Co., Cleveland, died Nov. 26. He had held the position for 32 years.

A. Fisher, cleaning room foreman, Zenith Foundry Co., Milwaukee, and a member, AFS Milwaukee Chapter, died Oct. 26.

A. S. Bixby, 60, manager of the Melrose Plant, National Malleable & Steel Castings Co., Melrose Park, Ill., died Nov. 6. He joined the staff of the firm's Chicago Works in 1926 as plant engineer and was transferred to the Melrose Plant in 1939 as general

A. S. Bixby

superintendent. He was appointed plant manager in 1954. Bixby was a member, AFS Chicago Chapter; and also held memberships in the Industrial Society of Chicago, Society for Advancement of Management, Industrial Relations Association of Chicago, and was serving on the Advisory Committee, Navy Pier Branch, Foundry Educational Foundation.

G. T. Calhoun, 46, foundry foreman, Caterpillar Tractor Co., Peoria, Ill., died Nov. 7. He was a member, AFS Central Illinois Chapter.

J. H. Williamson, former employee of M. A. Bell Co., St. Louis, died Nov. 30. He was chairman, St. Louis AFS Chapter, 1950-51.

classified advertising

Help Wanted

Foundry Supply Co. requires the services of a sales representative to sell supplies and equipment in Western New York and Western Pennsylvania. Excellent opportunity for man with foundry experience and sales ability. **Box F-110, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SALESMAN WANTED

Young progressive midwestern steel castings company needs traveling salesman or sales engineer for representation in five state Middle West area. Either some formal engineering education or former casting experience desirable. Send recent snapshot along with experience data. **Box F-112, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SAND TECHNOLOGIST

A young man experienced in sand control. One who can conduct and evaluate experimental programs on foundry sands and refractories, prepare reports and present them. A working knowledge of chemistry essential. Some traveling necessary. **Box F-100, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

IRON FOUNDRY METALLURGIST

required for foundry service work. Must have thorough knowledge of cupola operation and metallurgy of cast iron. Malleable and ductile iron experience desirable. Must be willing to travel. Salary open. Furnish resumé stating age, education and experience.

Box F-103, MODERN CASTINGS
Golf and Wolf Roads, Des Plaines, Ill.

EXPERIENCED GRAY IRON FOUNDRY SUPERINTENDENT

Familiar with squeezer, roll-over and bench work, capable of mixing metals, experience desirable but not necessary in ductile metal. Lancaster, Penna. Send resumé, availability and salary requirements to **Box F-106, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

Experienced Foundryman to operate and manage foundry. Must like people and be able to explain operations to audience. Excellent job for retired foundryman. Full or part time.

Contact: **Mr. Joseph Pater,**
Museum of Science and Industry, Chicago, Ill.
MU 4-1414 for detailed information.

SALES ENGINEER — ILLINOIS, WISCONSIN AREA

Familiar with ferrous and non-ferrous foundry practice to call on foundries, steel mills, etc. with top line refractory products, in midwest territory. College graduate or equivalent to qualify.

Established, reliable company has opening for aggressive man 25-35. Offers salary, commission plus automobile and many other benefits to man selected. Submit complete resume to

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$8,000 — $10,000

With orders from his doctor to slow down, this president is now ready to take on a practical foundryman and groom him to take over. A degree would be helpful but not necessary if practical experience is well rounded, especially in gray iron casting. Orientation will be short but all inclusive. Your ability and talent will grow under his guidance. The benefits and future leave little to be desired. Also he'll pay all expenses and fees.

Ask for Don Wunder
Business Men's Clearing House
209. S. State St. HA7-4577 Chicago, Ill.

METALLURGIST

Excellent opportunity for young man 25-35 years old. Experienced in malleable iron preferred. Mechanized foundry located in Midwest.

Write giving details of education, experience, availability, and other requirements.

Box F-113, MODERN CASTINGS,
Golf and Wolf Roads, Des Plaines, Ill.

SUPERINTENDENT
Production Brass Foundry

Well-established Michigan firm has need for man experienced in all phases of foundry operation. All resumé information held in strictest confidence.

Box F-107
MODERN CASTINGS,
Golf and Wolf Roads, Des Plaines, Ill.

PLANT MANAGER—INVESTMENT CASTINGS: New investment casting plant opened by established Midwest foundry. Experienced man required to assume complete responsibility for management of personnel, production, purchasing, tooling design, cost estimating. Must be strong in latest methods and metallurgy, ferrous and non-ferrous. Send complete resumé. **Box F-102, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

METALLURGIST

Well-established steel foundry in the East requires a metallurgist with experience in the manufacture of carbon, low-alloy and stainless steel castings. Must be capable of assuming full charge of expanding metallurgical department. Attractive long term opportunity. **Box F-115, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SUPERINTENDENT FOUNDRY

Career opportunity for man experienced in production of high quality carbon and allow steel pressure containing castings ranging from several pounds to 5 tons. Electric arc and induction melting facilities. Complete range of molding, coremaking, heat treating, and welding facilities. Position requires administrative ability to coordinate entire foundry operation.

Broad experience in all phases of production involving large number of pattern changes. Age no barrier for the right man. Benefits above average.

Send full resumé of experience and qualifications with recent photo if possible. All replies will be treated confidentially.

Box F-111, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

Positions Wanted

SUPERINTENDENT — METALLURGIST 20 years in iron jobbing up to 20 tons. Experience includes laboratory, cupola operation, metal mixtures, sand control, gating, risering and cause and remedy of casting defects. **Box F-101, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

Manager or General Superintendent. 26 years experience covering all phases of operation in medium sized, Midwestern malleable foundry. Presently employed but position unsatisfactory. Salary open. **Box F-105, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

Molding foreman desires position in steel foundry. 10 years experience. Have completed course in supervision and blueprint reading. Prefer Milwaukee area but will relocate. Age 32. Married. **Box F-108, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

EXPERIENCED FOUNDRYMAN available. Eight years experience in foundry work *magnaflux inspection*, chemical laboratory and supervision of sand testing laboratory. Also experienced with hydro-blast sand scrubbers and sand systems. Five years in foundry sand control. **Box F-114, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

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FOR SALE—2 WHITING No. 5 CUPOLAS

with charging equipment, blowers, air controls and charging buckets. New 1947, used two months.

Price reasonable for quick sale.

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Used #714 PJ Osborn Molding (Jolt - Squeeze - Strip).

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foundry trade news

Continued from page 142

new plant facilities in Niagara Falls. Construction for manufacture of 4 in. to 14 in. grinding wheels were immediately scheduled. Plant will incorporate results of two years of engineering developments and although not fully automatic, will feature important specially designed automatic and semi-automatic equipment.

Sully Castings Limited . . . is new name of Sherratt Brass Foundry Ltd., Richmond Hill, Ontario. Sherratt has been a highly regarded name in the non-ferrous field and the new name will be more easily connected with the business and its operations. The company has movel to a new modern foundry with improved equipment and working conditions.

Chicago Hardware Foundry Co. . . . North Chicago, Ill., is erecting, a year ahead of schedule, a new 8000 square feet aluminum brass foundry building to meet the growing demand for nonferrous castings. The early addition of the plant will complete three year modernization and expansion program.

Hansberg Shooters, Inc., of America . . . has been incorporated to import, manufacture, sell and distribute a line of foundry core and molding machines. William Geisler, president, is not a newcomer in foundry equipment industry, and thoroughly trained in technical and practical aspects of the industry. While visiting in Germany in 1954, Geisler became interested in a method of shooting sand into cores and molds known as Hansberg Shooter method and proposed introduction of these machines in the American market. The machines are built in Italy, Germany, Spain and Argentina. They make-up 80 per cent of the core-making machines and other foundry equipment used in Europe.

OLIVER No. 21 Lathe is versatile, powerful . . . it reduces the costs of turning large patterns

This Oliver pattern lathe is one of a full line found in leading pattern shops. Swings 92" diameter over sole plate, 10" over floor, and any desired diameter over pit at rear of headstock. Between centers it trims 6'6", or lathe can be made special for greater lengths. A 5 h-p. belted motor gives wide range of headstock speeds. Sole plate built any length. Write for Bulletin 21.

OLIVER Machinery Co., Grand Rapids 2, Mich.

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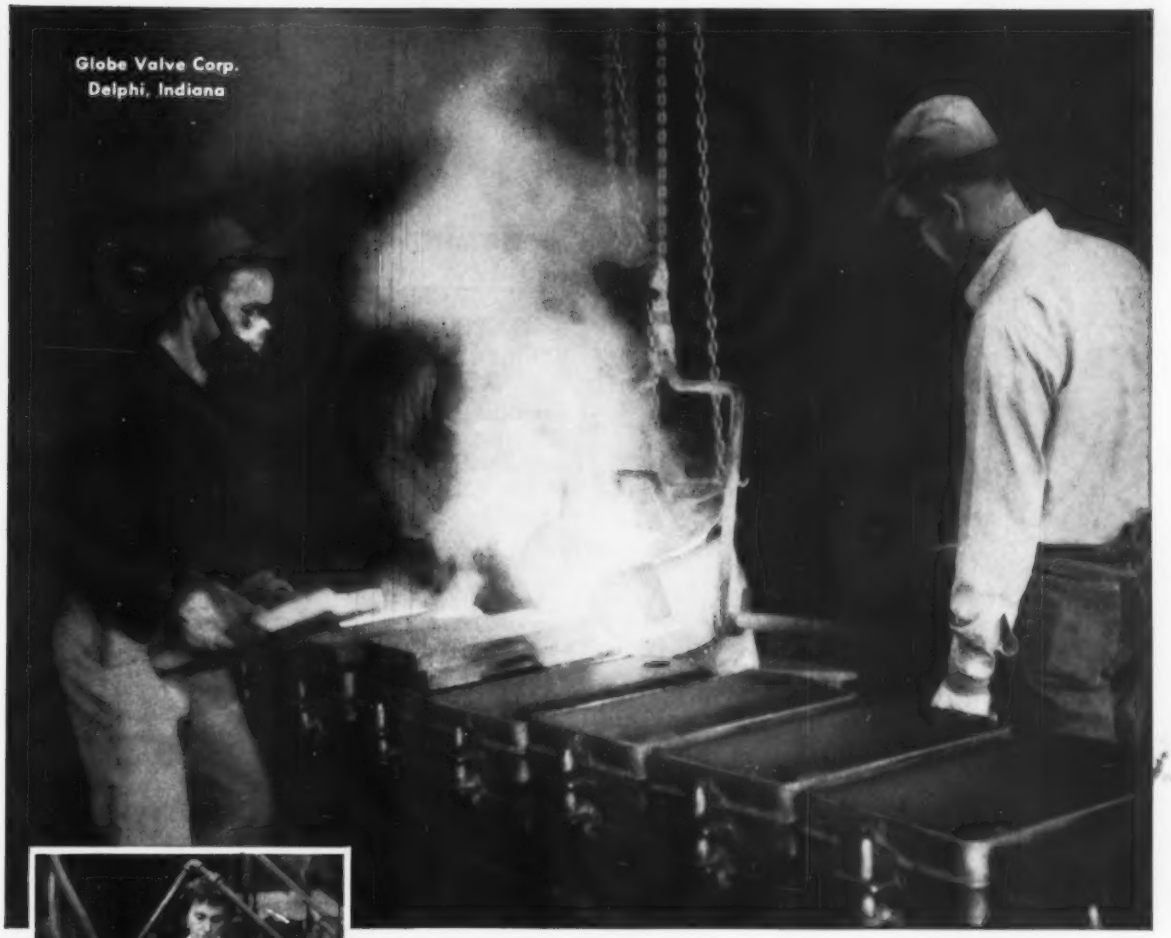
classified advertising rates

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . . 25¢ per word, 30 words ($7.50) minimum, prepaid. **Positions Wanted . . .** 10¢ per word, 30 words ($3.00) minimum, prepaid. Box number, care of MODERN CASTINGS, counts as 10 additional words.

Display Classified . . . Based on per-column width, per inch . . . 1 time, $18.00; 6-time, $16.50 per insertion; 12-time, $15.00 per insertion, prepaid.

Members of American Foundrymen's Society seeking employment in the metal-castings business may place one classified ad of 40 words in the "Positions Wanted" column FREE OF CHARGE. Inquiries will be kept confidential if requested. Ads may be repeated in following issues at regular rates.



The Air Pressure Test is given to all Globe castings. Here, casting is subjected to 160 pounds of pressure. Others are given similar test under water. All must be perfect.

Intricate Core is typical of many produced by Globe Valve Corp. using Cities Service Delco #60 Core Oil. Here, the oil's green strength is particularly important.

Production up 30% in two years

Using Cities Service Delco Core Oil, Globe Valve Corp. sets quality standard that sends sales soaring.

With production up 30% during the past two years, Globe Valve Corp., makers of GERBER brand plumbing fixtures, is now pouring 11-million brass castings a year!

Key to this outstanding success is strictest quality control . . . control that extends to the nearly nine million cores required in this operation and their priceless ingredient, core oil.

Here, Globe gets the quality it demands from Cities Service Delco #60. Not in any vague sense, but in four easily demonstrable characteristics:

- Fast bake allowing high rate of output, greater total productions.
- Good collapsibility
- Good storage qualities
- Good green strength, so important with intricate cores.

Wherever production schedules are tight . . . wherever quality is paramount . . . wherever cores are difficult to make . . . that's where you'll find Cities Service Delco Core Oils. Get the facts from a Cities Service Lubrication Engineer. Or write: Cities Service Oil Co., 20 North Wacker Drive, Chicago 6, Illinois.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

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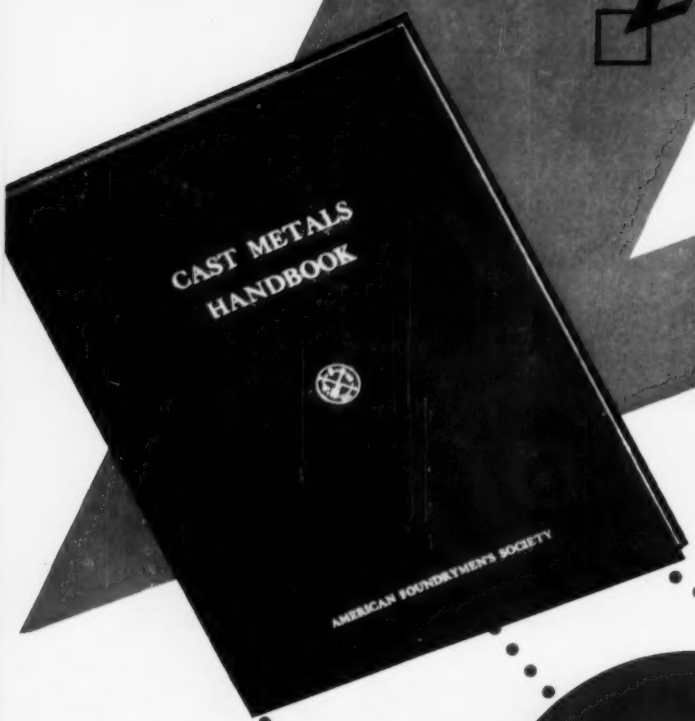
CAST METALS Handbook

AUTHORITATIVE REFERENCE FOR DESIGN-ENGINEERS

BASIC CREATIVE KNOW-HOW IN METAL



Industrial development, change and new product opportunities have created a demand for an essential engineering reference volume. The new Fourth Edition of the CAST METALS HANDBOOK brings existing information on cast metals up to-the-minute.

Constant research in industry results in constantly increasing new developments in materials and science. It's when the developments reach the Design-Engineer for conversion into components and end products that the CAST METALS HANDBOOK becomes an indispensable source of information.

Every chapter of the revised edition is reworked and augmented, with such completely new sections as: Casting Design, Cross Index of Equivalent Ferrous and Nonferrous Casting Alloy Specifications, Heat Treatment of Gray Iron, Pearlitic Malleable Iron, Nodular Cast Iron, Titanium-Base Alloys and Zinc-Base Alloys.

The NEW Cast Metals Handbook

CONTAINS:

1 Reliable working data for utilizing the properties of cast metals to the greatest engineering advantages.

2 Unbiased and authoritative information on new, reliable developments in cast materials.

3 Practical, up-to-date facts on HOW to get the most out of castings designs.

$10.00 List Price

Available to AFS Members at **$7.00**

Evidence

of the value of the Cast Metals Handbook is indicated in the sale of 10,000 copies of the previous edition . . . and this Fourth Edition is completely modernized and enlarged. EVERY MODERN-THINKING PRODUCT-DESIGNER NEEDS THIS HANDBOOK!

AMERICAN FOUNDRYMEN'S SOCIETY { Golf & Wolf Roads, Des Plaines, Illinois

Please forward . . . . . copies of the 1957 Edition of the AFS CAST METALS HANDBOOK. ☐ I am an AFS Member. ☐ I am not an AFS Member. I enclose $ . . . . . In ☐ Money Order ☐ Check ☐ Send Invoice

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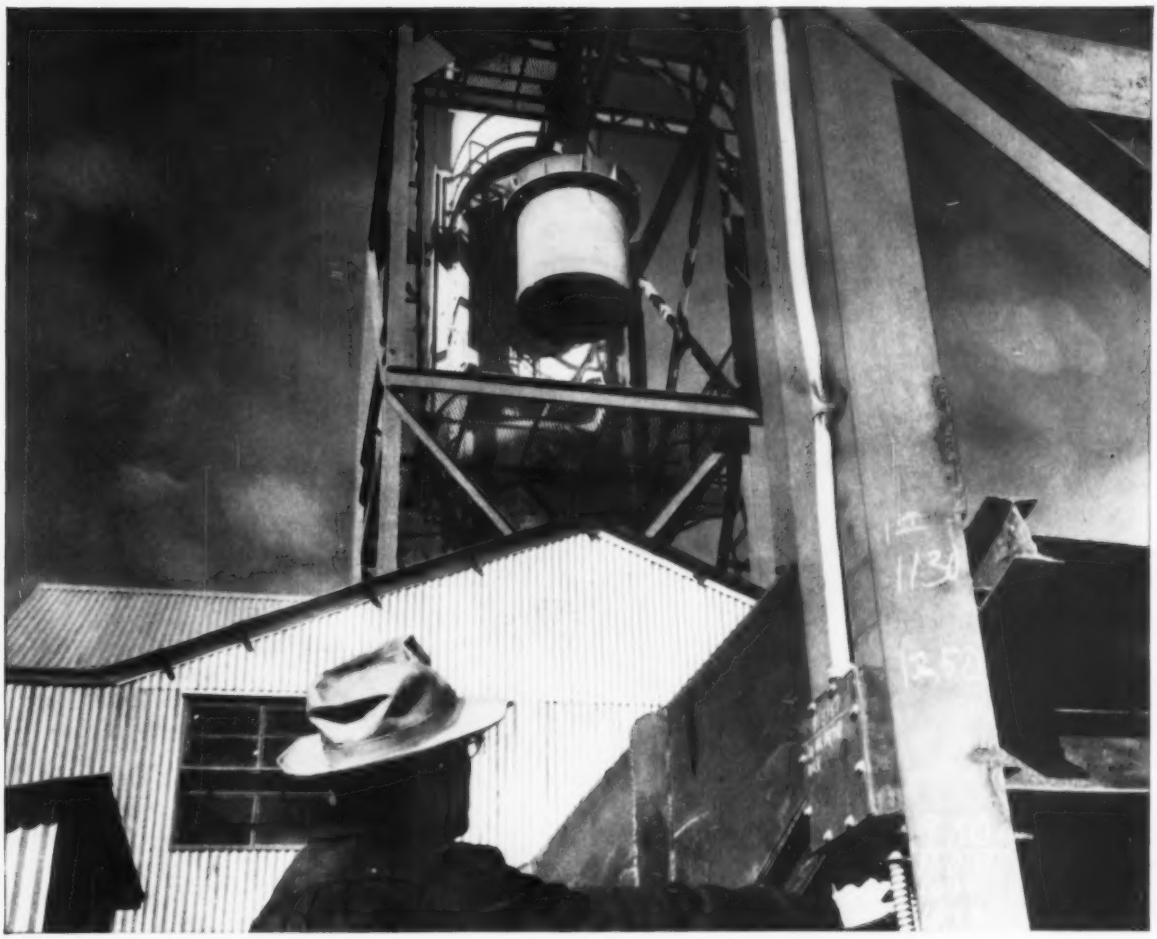

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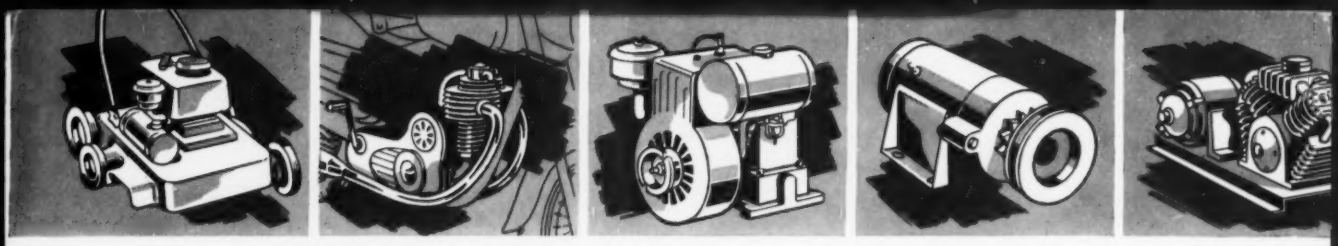

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